# **Supplementary Information**

# Late-stage oxidative C(sp<sup>3</sup>)–H methylation

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#### I. General information

All C-H oxidations were run under air with no precautions taken to exclude moisture. All other reactions were run under nitrogen atmosphere with dry solvent in flame-dried glassware unless otherwise noted. Dry solvents tetrahydrofuran (THF), methylene chloride (CH<sub>2</sub>Cl<sub>2</sub>), diethyl ether (Et<sub>2</sub>O), dimethylsulfoxide (DMSO), and acetonitrile (MeCN) were purified prior to use by passage through a bed of activated alumina (Glass Contour, Laguna Beach, CA). Commercially available reagents that were used as received are noted in the individual reaction procedures. Trimethylaluminum (AlMe<sub>3</sub>), DAST, TFAA, and BF<sub>3</sub>•OEt<sub>2</sub> were purchased from Millipore-Sigma. TMSOTf was purchased from Oakwood Chemical. (*R*,*R*)- and (*S*,*S*)-Fe(PDP)<sup>1</sup>, Fe(CF<sub>3</sub>PDP)<sup>2</sup>, Mn(CF<sub>3</sub>PDP) 1<sup>3</sup>, Mn(PDP)<sup>3</sup>, and Mn(PDP)(OTf)<sub>2</sub><sup>4</sup> were prepared according to literature procedures and stored in the fridge. Prior to use, catalysts were warmed to room temperature and weighed out in air. Thin-layer chromatography (TLC) was conducted with E. Merck TLC silica gel 60 F<sub>254</sub> pre-coated plates (0.25 mm) or E. Merck TLC aluminum oxide 60 F<sub>254</sub>, basic, pre-coated glass backed plates. Visualization was conducted with UV, CAM stain, and potassium permanganate (KMnO<sub>4</sub>) stain. Flash chromatography was performed using ZEOprep 60 ECO 43-60 micron silica gel (American International Chemical, Inc.) or basic aluminum oxide, Brockmann grade III (6% H<sub>2</sub>O added to Brockmann grade I) prepared from Alfa Aesar aluminum oxide, activated, basic, Brockmann grade I, 58 angstroms, 60 mesh power, S.A. 150m<sup>2</sup>/g, CAS: 1344-28-1. Medium pressure liquid chromatography was performed on a Teledyne Isco CombiFlash Rf machine using prepacked RediSep columns.

<sup>1</sup>H-NMR spectra were recorded on a Varian Unity Inova 400 (400 MHz), Varian VXR 500 (500 MHz), Varian Unity 500 (500 MHz), or Carver-Bruker 500 (500 MHz) spectrometer and are reported in ppm using solvent as an internal standard (CDCl<sub>3</sub> at 7.26 ppm). Data reported as: s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, sxt = sextet, hept = septet, m = multiplet, br = broad, app = apparent; coupling constant(s) in Hz; integration. Proton-decoupled <sup>13</sup>C-NMR spectra were recorded on a Varian Unity 500 (125 MHz) or Carver-Bruker 500 (125MHz) spectrometer and are reported in ppm using solvent as an internal standard (CDCl<sub>3</sub> at 77.16 ppm). <sup>19</sup>F spectra were recorded on a Varian Unity-500 (470 MHz), Varian Unity-500 (470 MHz) or Carver-Bruker 500 (470 MHz) and are reported in ppm using FCCl<sub>3</sub> (0 ppm) as an external standard. Labeled solvent impurities were calculated out when reporting isolated yields. High-resolution mass spectra were obtained at the University of Illinois Mass Spectrometer.

# **II. Optimization data**

	(1 equiv.)	Hydroxylation <sup>a</sup>		М	ethylation						
x (		1. Catalyst, H <sub>2</sub> O <sub>2</sub> AcOH, MeCN, -36 °C, 1 h		-Ar 2. Ar	dditive lu] (3 equiv.) H₂Cl₂ °C to rt, 4 h	X N-Ar Me		I—Ar ₿			) N—Ar
2 S	, X = CH <sub>2</sub> 1, X = O	4a (O	H), R = H; 4a (OA S2, R = H; S3, F	<b>c)</b> , R = Ac, X = CH <sub>2</sub> = Ac, X = O		<b>3</b> , X = CH <sub>2</sub> <b>7</b> , X = O	4b		4c	S4	
Entry	Substr.	Catalyst	Loading (mol%)	Additive	[Nu]	4a (OH)/ S2 (%)	4a (OAc)/ S3 (%)	3/7 (%)	<b>4b</b> (%)	4c/S4 (%)	rsm (%)
Oxidation											
1 <sup>b</sup>	2	Fe(PDP)	3 x 5	-	-	$<5^k$	0	-	<5 <sup>k</sup>	-	0
2°	2	Fe(CF <sub>3</sub> PDP)	3 x 5	-	-	8 <sup>k</sup>	0	-	6 <sup>k</sup>	-	0
3 <sup>d</sup>	2	Mn(PDP)(OTf) <sub>2</sub>	1	-	-	12	0	-	0	-	75
4	2	$Mn(PDP)(SbF_6)_2$	1	-	-	28	7	-	<5 <sup>k</sup>	-	35
5 <sup>e</sup>	2	Mn(CF <sub>3</sub> PDP) 1	10	-	-	13 <sup>k</sup>	10	-	41	-	0
6	2	1	1	-	-	51	21	-	9	-	0
7	2	1	0.5	-	-	64	18	-	<5 <sup>k</sup>	-	4
Methylation											
8 <sup>f</sup>	2	1	0.5	$BF_3 \bullet OEt_2$	AlMe <sub>3</sub>	<5 <sup>k</sup>	0	63	<5 <sup>k</sup>	0	11
$9^{\rm f}$	<b>S1</b>	1	0.5	BF <sub>3</sub> •OEt <sub>2</sub>	AlMe <sub>3</sub>	11	5	10	-	4	27
10 <sup>g</sup>	<b>S1</b>	1	0.5	DAST	AlMe <sub>3</sub>	0	14 <sup>k</sup>	55	-	0	16
11 <sup>g</sup>	2	1	0.5	DAST	AlMe <sub>3</sub>	0	0	64	<5 <sup>k</sup>	0	12
12 <sup>g</sup>	2	1	0.5	Deoxo- Fluor	AlMe <sub>3</sub>	0	0	61	6	0	5
13 <sup>h</sup>	2	1	0.5	TFAA/ TMSOTf	AlMe <sub>3</sub>	0	0	51	<5 <sup>k</sup>	14	9
14 <sup>h</sup>	<b>S1</b>	1	0.5	TFAA/ TMSOTf	AlMe <sub>3</sub>	0	0	46	-	20	13
15 <sup>i</sup>	2	1	0.5	MsCl/Et <sub>3</sub> N	AlMe <sub>3</sub>	15	0	0	<5 <sup>k</sup>	39	6
16 <sup>g</sup>	2	1	0.5	DAST	ZnMe <sub>2</sub>	17	9	0	11	0	14
17 <sup>g,j</sup>	2	1	0.5	DAST	MeMgBr	24	$< 5^k$	24	<5 <sup>k</sup>	0	9

Table 1 | Development of Mn(CF<sub>3</sub>PDP) 1-mediated oxidative methylation

**Extended Data Table 1. Reaction optimization.** <sup>a</sup>General oxidation (unless otherwise noted): **2** (0.3 mmol), catalyst (x mol%, (*R*,*R*) and (*S*,*S*) used interchangeably), AcOH (15 equiv.), MeCN (0.5 M), -36 <sup>o</sup>C; H<sub>2</sub>O<sub>2</sub> (2 equiv.) in MeCN (3.75 mL) syringe pump 1 h. Mixture passed through silica plug, EtOAc flush, concentrated prior to isolation or methylation. Isolated product yields. <sup>b</sup> Procedure ref. 28. <sup>c</sup> Procedure ref. 29. <sup>d</sup>Procedure ref. 31. <sup>e</sup>5 equiv. H<sub>2</sub>O<sub>2</sub>. <sup>f</sup>General BF<sub>3</sub> alkylation: crude in CH<sub>2</sub>Cl<sub>2</sub> (0.2 M), -78 <sup>o</sup>C, AlMe<sub>3</sub> (3 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (2 equiv.) sequentially added, stirred 1 h; room temperature (rt) for 3 h. <sup>g</sup>General fluorine alkylation: crude in CH<sub>2</sub>Cl<sub>2</sub> (0.2 M), fluorine additive (1 equiv.) added at -78 <sup>o</sup>C; rt for 1 h; cooled to -78 <sup>o</sup>C, nucleophile (3 equiv.) added, stirred 2 h; rt for 1 h. <sup>h</sup>General TMSOTf alkylation: crude in CH<sub>2</sub>Cl<sub>2</sub> (0.2 M), TFAA (1 equiv.) added, stirred 1 h; cooled to -78 <sup>o</sup>C, AlMe<sub>3</sub> (3 equiv.) added, stirred 1 h; washed NaHCO<sub>3</sub>, dried, reduced; redissolved in CH<sub>2</sub>Cl<sub>2</sub>, AlMe<sub>3</sub> (3 equiv.) added at -78 <sup>o</sup>C, stirred 1 h; washed NaHCO<sub>3</sub>, dried, reduced; redissolved in CH<sub>2</sub>Cl<sub>2</sub>, AlMe<sub>3</sub> (3 equiv.) added at -78 <sup>o</sup>C, stirred 2 h; rt for 1 h. <sup>h</sup>MeMgBr (3 equiv.) added at -78 <sup>o</sup>C, stirred 3 h. <sup>k</sup>Yield by crude <sup>1</sup>H NMR.

#### Procedure A for reaction optimization studies (substrate oxidation)

In a 40 mL vial the starting material (0.30 mmol, 1.0 equiv.) and the catalyst ((*R*,*R*)- and (*S*,*S*)enantiomers were used interchangeably for achiral substrates) were dissolved in MeCN (0.6 mL, 0.50 M). AcOH (256  $\mu$ L, 4.50 mmol, 15.0 equiv.) was then added. A 10 mL syringe was charged with a solution of H<sub>2</sub>O<sub>2</sub> (34.3  $\mu$ L, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.16 M), and fitted with a 25G needle. The vial was sealed with a screw cap fitted with a PTFE/Silicone septum and cooled to -36 °C with a 1,2-DCE/dry ice bath. The H<sub>2</sub>O<sub>2</sub> solution was added into the stirring reaction mixture via a syringe pump at 3.75 mL/h. Upon completion, the reaction mixture was added via syringe onto a 15 mL silica plug and allowed to sit for 5 min to ensure complete H<sub>2</sub>O<sub>2</sub> consumption. EtOAc (150 mL) was then allowed to pass through the silica plug. The resulting solution was condensed under vacuum and purified by flash chromatography (50 mL silica, 20% $\rightarrow$ 30% $\rightarrow$ 40% $\rightarrow$ 50% $\rightarrow$ 75% EtOAc/Hex).

# Procedure B for reaction optimization studies (BF3-assisted methylation)

The starting material was oxidized according to procedure A for reaction optimization studies. Upon passing through the silica plug, the resulting solution was condensed and transferred into a 25 mL recovery flask. The solvents were removed through rotary evaporation, and the residual acetic acid was removed under vacuum overnight. The crude was backfilled with nitrogen 3x, redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL), and cooled to -78 °C with an acetone/dry ice bath. Trimethylaluminum (2 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added dropwise, followed by boron trifluoride diethyl ether complex (74.1  $\mu$ L, 0.60 mmol, 2.0 equiv.). The mixture was stirred at -78 °C for 1 h, then allowed to gradually warm up while further stirring for 3 h. Upon completion, the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> and poured into a 60 mL separatory funnel with 5 mL 1 M NaOH. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> twice and the organic layers were combined, dried over MgSO<sub>4</sub>, filtered, condensed, and purified by flash chromatography (50 mL silica, 10% $\rightarrow$ 20% $\rightarrow$ 30% EtOAc/Hex).

#### **Procedure C for reaction optimization studies (fluorine-assisted methylation)**

The starting material was oxidized according to procedure A for reaction optimization studies. Upon passing through the silica plug, the resulting solution was condensed and transferred into a 25 mL recovery flask. The solvents were removed through rotary evaporation, and the residual acetic acid was removed under vacuum overnight. The crude was backfilled with nitrogen 3x, redissolved in  $CH_2Cl_2$  (1.5 mL), and cooled to -78 °C with an acetone/dry ice bath. The fluorinating reagent (0.30 mmol, 1.0 equiv.) was added, and the reaction was allowed to warm up to room temperature while stirring for 1 h. The flask was then again placed in -78 °C cold bath, and trimethylaluminum (2 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.) was added dropwise. The mixture was stirred at -78 °C for 2 h, then allowed to gradually

warm up while further stirring for 1 h. Upon completion, the reaction mixture was diluted with  $CH_2Cl_2$ and poured into a 60 mL separatory funnel with 5 mL 1 M NaOH. The aqueous layer was extracted with  $CH_2Cl_2$  twice and the organic layers were combined, dried over MgSO<sub>4</sub>, filtered, condensed, and purified by flash chromatography (50 mL silica, 10% $\rightarrow$ 20% $\rightarrow$ 30% EtOAc/Hex).

Entry 1. According to literature<sup>5</sup>, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) in a 40 mL vial was dissolved in MeCN (0.6 mL). The vial was placed into an ice bath and allowed to stir for 30 s, and AcOH (8.6  $\mu$ L, 0.15 mmol, 0.5 equiv.) was added, followed by a solution of Fe(PDP) (14.0 mg, 0.015 mmol, 0.05 equiv.) in MeCN (0.3 mL). A solution of H<sub>2</sub>O<sub>2</sub> (35.0  $\mu$ L, 0.57 mmol, 1.9 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN (4.5 mL) at 0 °C was added dropwise via a pipet to the stirring solution over 2-3 minutes. After 10 min, a second portion of AcOH and Fe(PDP) were added to the reaction mixture, followed by the dropwise addition of a second portion of H<sub>2</sub>O<sub>2</sub> solution in MeCN as described above. After an additional 10 minutes, a third portion of H<sub>2</sub>O<sub>2</sub> solution in MeCN as described above. The reaction solution was stirred for 10 minutes after the last iterative addition, for a total reaction time of approximately 36 minutes. Upon completion, the reaction mixture was added via syringe onto a 15 mL silica plug and allowed to sit for 5 min to ensure complete H<sub>2</sub>O<sub>2</sub> consumption. EtOAc (150 mL) was then allowed to pass through the silica plug. The resulting solution was condensed under vacuum.

**Run 1** (trace **4a** (**OH**) by <sup>1</sup>H NMR; trace **4b** by <sup>1</sup>H NMR; 0% rsm)

**Run 2** (trace **4a** (**OH**) by <sup>1</sup>H NMR; trace **4b** by <sup>1</sup>H NMR; 0% rsm)

**Run 3** (trace **4a** (**OH**) by <sup>1</sup>H NMR; trace **4b** by <sup>1</sup>H NMR; 0% rsm)

#### Average overall yield: Trace 4a (OH) and 4b, 0% RSM

**Entry 2.** According to literature<sup>5</sup>, **2** (58.7 mg, 0.30 mmol, 1.0 equiv.) in a 40 mL vial was dissolved in MeCN (0.6 mL). The vial was placed into an ice bath and allowed to stir for 30 s, and AcOH (8.6  $\mu$ L, 0.15 mmol, 0.5 equiv.) was added, followed by a solution of Fe(CF<sub>3</sub>PDP) (20.3 mg, 0.015 mmol, 0.05 equiv.) in MeCN (0.3 mL). A solution of H<sub>2</sub>O<sub>2</sub> (35.0  $\mu$ L, 0.57 mmol, 1.9 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN (4.5 mL) at 0 °C was added dropwise via a pipet to the stirring solution over 2-3 minutes. After 10 min, a second portion of AcOH and Fe(CF<sub>3</sub>PDP) were added to the reaction mixture, followed by the dropwise addition of a second portion of H<sub>2</sub>O<sub>2</sub> solution in MeCN as described above. After an additional 10 minutes, a third portion of H<sub>2</sub>O<sub>2</sub> solution in MeCN as described above. The reaction solution was stirred for 10 minutes after the last iterative addition, for a total reaction time of approximately 36 minutes. Upon completion, the reaction mixture was added via syringe onto a 15 mL silica plug and

allowed to sit for 5 min to ensure complete  $H_2O_2$  consumption. EtOAc (150 mL) was then allowed to pass through the silica plug. The resulting solution was condensed under vacuum.

**Run 1** (8% 4a (OH) by <sup>1</sup>H NMR; 6% 4b by <sup>1</sup>H NMR; 0% rsm)

**Run 2** (7% **4a** (**OH**) by <sup>1</sup>H NMR; 6% **4b** by <sup>1</sup>H NMR; 0% rsm)

**Run 3** (10% **4a (OH)** by <sup>1</sup>H NMR; 6% **4b** by <sup>1</sup>H NMR; 0% rsm)

# Average overall yield: 8% 4a (OH), 6% 4b, 0% RSM

Entry 3. According to literature<sup>4</sup>, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) and Mn(PDP)(OTf)<sub>2</sub> (2.0 mg, 0.003 mmol, 0.01 equiv.) were dissolved in MeCN (1.2 mL, 0.25 M). AcOH (223  $\mu$ L, 3.90 mmol, 13.0 equiv.) was then added. A 10 mL syringe was charged with a solution of H<sub>2</sub>O<sub>2</sub> (60.1  $\mu$ L, 1.05 mmol, 3.5 equiv, 30 wt.% in H<sub>2</sub>O) in MeCN (0.7 mL, 1.5 M), and fitted with a 25G needle. The vial was sealed with a screw cap fitted with a PTFE/Silicone septum and cooled to -40 °C with an acetonitrile/dry ice bath. The H<sub>2</sub>O<sub>2</sub> solution was added into the stirring reaction mixture via a syringe pump at 1.40 mL/h. Upon completion, the reaction mixture was added via syringe onto a 15 mL silica plug. EtOAc (150 mL) was then allowed to pass through the silica plug. The resulting solution was condensed under vacuum and purified by flash chromatography (50 mL silica, 10% $\rightarrow$ 20% $\rightarrow$ 30% EtOAc/Hex).

Run 1 (6.6 mg, 0.031 mmol, 10% 4a (OH); 41.6 mg, 0.213 mmol, 71% rsm)

Run 2 (9.4 mg, 0.044 mmol, 15% 4a (OH); 47.0 mg, 0.240 mmol, 80% rsm)

Run 3 (7.7 mg, 0.036 mmol, 12% 4a (OH); 44.3 mg, 0.227 mmol, 75% rsm)

# Average overall yield: 12% 4a (OH), 75% RSM

Entry 4. According to procedure A for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using  $Mn(PDP)(MeCN)_2(SbF_6)_2$  (2.8 mg, 0.003 mmol, 0.01 equiv.).

**Run 1** (20.2 mg, 0.0954 mmol, 32% **4a (OH)**; 2.5 mg, 0.0099 mmol, 3% **4a (OAc)**; trace **4b** by <sup>1</sup>H NMR; 17.7 mg, 0.0906 mmol, 30% rsm)

**Run 2** (19.0 mg, 0.0817 mmol, 27% **4a (OH)**; 7.4 mg, 0.029 mmol, 10% **4a (OAc)**; trace **4b** by <sup>1</sup>H NMR; 19.1 mg, 0.0976 mmol, 33% rsm)

**Run 3** (16.7 mg, 0.0787 mmol, 26% **4a** (**OH**); 5.1 mg, 0.020 mmol, 7% **4a** (**OAc**); trace **4b** by <sup>1</sup>H NMR; 25.0 mg, 0.128 mmol, 43% rsm)

# Average overall yield: 28% 4a (OH), 7% 4a (OAc), trace 4b, 35% RSM

Entry 5. According to procedure A for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using Mn(CF<sub>3</sub>PDP)(MeCN)<sub>2</sub>(SbF6)<sub>2</sub> (40.7 mg, 0.03 mmol, 0.1 equiv.) and H<sub>2</sub>O<sub>2</sub> (85.8  $\mu$ L, 1.50 mmol, 5.0 equiv., 50 wt.% in H<sub>2</sub>O).

**Run 1** (16% **4a (OH)** by <sup>1</sup>H NMR; 7.9 mg, 0.031 mmol, 10% **4a (OAc)**; 23.7 mg, 0.118 mmol, 39% **4b**; 0% rsm)

**Run 2** (10% **4a (OH)** by <sup>1</sup>H NMR; 7.7 mg, 0.030 mmol, 10% **4a (OAc)**; 26.6 mg, 0.127 mmol, 42% **4b**; 0% rsm)

#### Average overall yield: 13% 4a (OH), 10% 4a (OAc), 41% 4b, 0% RSM

Entry 6. According to procedure A for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using  $Mn(CF_3PDP)(MeCN)_2(SbF_6)_2$  (4.1 mg, 0.003 mmol, 0.01 equiv.).

**Run 1** (31.9 mg, 0.151 mmol, 50% **4a** (**OH**); 14.3 mg, 0.0564 mmol, 19% **4a** (**OAc**); 9.7 mg, 0.038 mmol, 13% **4b**; 0% rsm)

**Run 2** (33.9 mg, 0.160 mmol, 53% **4a** (**OH**); 19.2 mg, 0.0755 mmol, 25% **4a** (**OAc**); 5.7 mg, 0.0272 mmol, 9% **4b**; 0% rsm)

**Run 3** (31.3 mg, 0.148 mmol, 49% **4a** (**OH**); 14.6 mg, 0.0574 mmol, 19% **4a** (**OAc**); 3.2 mg, 0.015 mmol, 5% **4b**; 0% rsm)

#### Average overall yield: 51% 4a (OH), 21% 4a (OAc), 9% 4b, 0% RSM

Entry 7. According to procedure A for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using  $Mn(CF_3PDP)(MeCN)_2(SbF_6)_2$  (2.0 mg, 0.0015 mmol, 0.005 equiv.).

**Run 1** (39.0 mg, 0.184 mmol, 61% **4a** (**OH**); 17.2 mg, 0.0681 mmol, 23% **4a** (**OAc**); trace **4b** by <sup>1</sup>H NMR; 2.7 mg, 0.014 mmol, 5% rsm)

**Run 2** (42.2 mg, 0.199 mmol, 66% **4a** (**OH**); 13.0 mg, 0.0513 mmol, 17% **4a** (**OAc**); trace **4b** by <sup>1</sup>H NMR; 4.7 mg, 0.024 mmol, 8% rsm)

**Run 3** (41.5 mg, 0.196 mmol, 66% **4a** (**OH**); 11.5 mg, 0.0543 mmol, 15% **4a** (**OAc**); trace **4b** by <sup>1</sup>H NMR; 0% rsm)

#### Average overall yield: 64% 4a (OH), 18% 4a (OAc), trace 4b, 4% RSM

Entry 8. According to procedure B for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was methylated using  $BF_3 \cdot OEt_2$  and  $AIMe_3$  as described.

**Run 1** (trace **4a** (**OH**) by <sup>1</sup>H NMR; 37.2 mg, 0.177 mmol, 59% **3**; trace **4b** by <sup>1</sup>H NMR; 9.9 mg, 0.051 mmol, 17% rsm)

**Run 2** (41.8 mg, 0.199 mmol, 66% **3**; trace **4b** by <sup>1</sup>H NMR; 4.1 mg, 0.021 mmol, 7% rsm)

**Run 3** (41.2 mg, 0.196 mmol, 65% **3**; trace **4b** by <sup>1</sup>H NMR; 5.3 mg, 0.027 mmol, 9% rsm)

#### Average overall yield: trace 4a (OH), 63% of 3, trace 4b, 11% RSM

Entry 9. According to procedure B for optimization studies, S1 (59.3 mg, 0.30 mmol, 1.0 equiv.) was methylated using  $BF_3 \cdot OEt_2$  and  $AIMe_3$  as described.

**Run 1** (3.5 mg, 0.015 mmol, 5% **S2**; 6.6 mg, 0.026 mmol, 9% **S3**; 6.2 mg, 0.029 mmol, 10% 7; 3.3 mg, 0.017 mmol, 6% **S4**; 14.0 mg, 0.0708 mmol, 24% rsm)

**Run 2** (10.9 mg, 0.0510 mmol, 17% **S2**; 0.8 mg, 0.003 mmol, 1% **S3**; 6.1 mg, 0.029 mmol, 10% 7; 1.7 mg, 0.0087 mmol, 3% **S4**; 18.3 mg, 0.0925 mmol, 31% rsm)

**Run 3** (6.3 mg, 0.029 mmol, 10% **S2**; 3.8 mg, 0.015 mmol, 5% **S3**; 7.2 mg, 0.034 mmol, 11% 7; 1.6 mg, 0.0082 mmol, 3% **S4**; 15.3 mg, 0.0774 mmol, 26% rsm)

#### Average overall yield: 11% S2, 5% S3, 10% 7, 4% S4, 27% RSM

Entry 10. According to procedure C for optimization studies, S1 (59.3 mg, 0.30 mmol, 1.0 equiv.) was methylated using DAST (39.6 μL, 0.30 mmol, 1.0 equiv.) and AlMe<sub>3</sub> as described. Run 1 (14% S3 by <sup>1</sup>H NMR; 35.9 mg, 0.170 mmol, 57% 7; 6.0 mg, 0.030 mmol, 10% rsm) Run 2 (17% S3 by <sup>1</sup>H NMR; 35.3 mg, 0.167 mmol, 56% 7; 6.6 mg, 0.033 mmol, 11% rsm) Run 3 (10% S3 by <sup>1</sup>H NMR; 33.2 mg, 0.157 mmol, 52% 7; 15.8 mg, 0.0800 mmol, 27% rsm)

### Average overall yield: 14% S3, 55% 7, 16% RSM

Entry 11. According to procedure C for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was methylated using DAST (39.6 μL, 0.30 mmol, 1.0 equiv.) and AlMe<sub>3</sub> as described. Run 1 (38.3 mg, 0.183 mmol, 61% 3; trace 4b by <sup>1</sup>H NMR; 7.2 mg, 0.037 mmol, 12% rsm) Run 2 (42.1 mg, 0.201 mmol, 67% 3; trace 4b by <sup>1</sup>H NMR; 4.1 mg, 0.021 mmol, 7% rsm) Run 3 (39.9 mg, 0.190 mmol, 63% 3; trace 4b by <sup>1</sup>H NMR; 10.0 mg, 0.0511 mmol, 17% rsm)

### Average overall yield: 64% of 3, trace 4b, 12% RSM

Entry 12. According to procedure C for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was methylated using Deoxo-Fluor (55.3 μL, 0.30 mmol, 1.0 equiv.) and AlMe<sub>3</sub> as described.
Run 1 (38.2 mg, 0.182 mmol, 61% 3; 7.6 mg, 0.036 mmol, 12% 4b by <sup>1</sup>H NMR; 0% rsm)
Run 2 (38.7 mg, 0.185 mmol, 62% 3; 1.8 mg, 0.0086 mmol, 3% 4b; 2.8 mg, 0.014 mmol, 5% rsm)
Run 3 (38.6 mg, 0.184 mmol, 61% 3; 1.3 mg, 0.0060 mmol, 2% 4b; 5.3 mg, 0.027 mmol, 9% rsm)

### Average overall yield: 61% of 3, 6% 4b, 5% RSM

Entry 13. According to a modified procedure C for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using  $Mn(CF_3PDP)(MeCN)_2(SbF_6)_2$  (2.0 mg, 0.0015 mmol, 0.005 equiv.) and worked up as described. The crude was backfilled with nitrogen 3x and redissolved in  $CH_2Cl_2$  (1.5 mL). Trifluoroacetic anhydride (41.7  $\mu$ L, 0.3 mmol, 1.0 equiv.) was added at room temperature, and the

reaction was stirred for 1 h. The reaction flask was then placed in a -78 °C acetone/dry ice bath, and trimethylaluminum (2 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added dropwise, followed by TMSOTf (54.3  $\mu$ L, 0.30 mmol, 1.0 equiv.). The mixture was stirred at -78 °C for 2 h, then allowed to gradually warm up while further stirring for 1 h before quenching as described.

**Run 1** (32.0 mg, 0.153 mmol, 51% **3**; trace **4b** by <sup>1</sup>H NMR; 9.5 mg, 0.049 mmol, 16% **4c**; 4.3 mg, 0.022 mmol, 7% rsm)

**Run 2** (34.2 mg, 0.163 mmol, 54% **3**; trace **4b** by <sup>1</sup>H NMR; 7.6 mg, 0.039 mmol, 13% **4c**; 7.1 mg, 0.036 mmol, 11% rsm)

**Run 3** (31.0 mg, 0.148 mmol, 49% **3**; trace **4b** by <sup>1</sup>H NMR; 7.0 mg, 0.036 mmol, 12% **4c**; 4.7 mg, 0.024 mmol, 8% rsm)

# Average overall yield: 51% of 3, trace 4b, 14% 4c, 9% RSM

Entry 14. According to a modified procedure C for optimization studies, S1 (59.3 mg, 0.30 mmol, 1.0 equiv.) was oxidized using Mn(CF<sub>3</sub>PDP)(MeCN)<sub>2</sub>(SbF<sub>6</sub>)<sub>2</sub> (2.0 mg, 0.0015 mmol, 0.005 equiv.) and worked up as described. The crude was backfilled with nitrogen 3x and redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL). Trifluoroacetic anhydride (41.7  $\mu$ L, 0.3 mmol, 1.0 equiv.) was added at room temperature, and the reaction was stirred for 1 h. The reaction flask was then placed in a -78 °C acetone/dry ice bath, and trimethylaluminum (2 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added dropwise, followed by TMSOTf (54.3  $\mu$ L, 0.30 mmol, 1.0 equiv.). The mixture was stirred at -78 °C for 2 h, then allowed to gradually warm up while further stirring for 1 h before quenching as described.

**Run 1** (26.8 mg, 0.127 mmol, 42% **7**; 9.7 mg, 0.050 mmol, 17% **S4**; 9.6 mg, 0.049 mmol, 16% rsm) **Run 2** (28.1 mg, 0.133 mmol, 44% **7**; 11.5 mg, 0.0588 mmol, 20% **S4**; 5.4 mg, 0.027 mmol, 9% rsm) **Run 3** (33.1 mg, 0.156 mmol, 52% **7**; 14.2 mg, 0.0726 mmol, 24% **S4**; 7.3 mg, 0.044 mmol, 15% rsm)

#### Average overall yield: 46% of 7, 20% S4, 13% RSM

Entry 15. According to a modified procedure C for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using Mn(CF<sub>3</sub>PDP)(MeCN)<sub>2</sub>(SbF6)<sub>2</sub> (2.0 mg, 0.0015 mmol, 0.005 equiv.) and worked up as described. The crude was backfilled with nitrogen 3x and redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL). MsCl (23.2  $\mu$ L, 0.3 mmol, 1.0 equiv.) and Et<sub>3</sub>N (41.8  $\mu$ L, 0.3 mmol, 1.0 equiv.) were added at room temperature, and the reaction was stirred for 1 h. Upon completion, the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub>, and poured into a 60 mL separatory funnel containing 5 mL NaHCO<sub>3</sub>. The aqueous layer was extracted with 5 mL CH<sub>2</sub>Cl<sub>2</sub> 2x, and the organic layers were combined, dried over MgSO4, condensed under vacuum, and transferred back into the 25 mL recovery flask. The crude was backfilled with N2 3x and 1.5 mL CH<sub>2</sub>Cl<sub>2</sub> was added. The reaction flask was then placed in a -78 °C acetone/dry ice bath, and

trimethylaluminum (2 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added dropwise. The mixture was stirred at -78 °C for 2 h, then allowed to gradually warm up while further stirring for 1 h before quenching as described.

**Run 1** (11.4 mg, 0.0539 mmol, 18% **4a (OH)**; trace **4b** by <sup>1</sup>H NMR; 19.7 mg, 0.102 mmol, 34% **4c**; 1.6 mg, 0.0082 mmol, 3% rsm)

**Run 2** (12.1 mg, 0.0575 mmol, 19% **4a** (**OH**); trace **4b** by <sup>1</sup>H NMR; 23.4 mg, 0.121 mmol, 40% **4c**; 2.5 mg, 0.013 mmol, 4% rsm)

**Run 3** (4.5 mg, 0.021 mmol, 7% **4a (OH)**; trace **4b** by <sup>1</sup>H NMR; 24.6 mg, 0.127 mmol, 42% **4c**; 7.1 mg, 0.036 mmol, 12% rsm)

#### Average overall yield: 15% 4a (OH), trace 4b, 39% 4c, 6% RSM

**Entry 16.** According to a modified procedure C for optimization studies, **2** (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using Mn(CF<sub>3</sub>PDP)(MeCN)<sub>2</sub>(SbF<sub>6</sub>)<sub>2</sub> (2.0 mg, 0.0015 mmol, 0.005 equiv.) and worked up as described. The crude was backfilled with nitrogen 3x, redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL), and cooled to -78 °C with an acetone/dry ice bath. DAST (39.6  $\mu$ L, 0.30 mmol, 1.0 equiv.) was added, and the reaction was allowed to warm up to room temperature while stirring for 1 h. The flask was then again placed in -78 °C cold bath, and dimethylzinc (2 M in toluene, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added dropwise. The mixture was stirred at -78 °C for 2 h, then allowed to gradually warm up while further stirring for 1 h before quenching as described.

**Run 1** (5.6 mg, 0.026 mmol, 9% **4a** (**OH**); 3.0 mg, 0.0018 mmol, 4% **4a** (**OAc**); trace **4b** by <sup>1</sup>H NMR; 14.6 mg, 0.0745 mmol, 25% rsm)

**Run 2** (15.3 mg, 0.0725 mmol, 24% **4a (OH)**; 6.9 mg, 0.027 mmol, 9% **4a (OAc)**; 10.8 mg, 0.0513 mmol, 17% **4b**; 0% rsm)

**Run 3** (10.9 mg, 0.0513 mmol, 17% **4a** (**OH**); 10.0 mg, 0.0393 mmol, 13% **4a** (**OAc**); trace **3** by <sup>1</sup>H NMR; 10.8 mg, 0.0513 mmol, 17% **4b**; 10.6 mg, 0.0542 mmol, 18% rsm)

# Average overall yield: 17% 4a (OH), 9% 4a (OAc), 11% 4b, 14% RSM

Entry 17. According to a modified procedure C for optimization studies, 2 (58.7 mg, 0.30 mmol, 1.0 equiv.) was oxidized using Mn(CF<sub>3</sub>PDP)(MeCN)<sub>2</sub>(SbF<sub>6</sub>)<sub>2</sub> (2.0 mg, 0.0015 mmol, 0.005 equiv.) and worked up as described. The crude was backfilled with nitrogen 3x, redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL), and cooled to -78 °C with an acetone/dry ice bath. DAST (39.6  $\mu$ L, 0.30 mmol, 1.0 equiv.) was added, and the reaction was allowed to warm up to room temperature while stirring for 1 h. The flask was then again placed in -78 °C cold bath, and MeMgBr (3 M in THF, 300  $\mu$ L, 0.90 mmol, 3.0 equiv.) was added

dropwise. The mixture was stirred at -78 °C for 3 h, then directly quenched with 1 M HCl (3 mL) without warming up.

**Run 1** (17.8 mg, 0.0841 mmol, 28% **4a (OH)**; trace **4a (OAc)** by <sup>1</sup> H NMR; 14.9 mg, 0.0709 mmol, 24% **3**; trace **4b** by <sup>1</sup>H NMR; 1.8 mg, 0.0092 mmol, 3% rsm)

**Run 2** (22.0 mg, 0.104 mmol, 35% **4a (OH)**; trace **4a (OAc)** by <sup>1</sup>H NMR; 16.3 mg, 0.0776 mmol, 26% **3**; trace **4b** by <sup>1</sup>H NMR; 7.6 mg, 0.039 mmol, 13% rsm)

**Run 3** (5.4 mg, 0.026 mmol, 9% **4a** (**OH**); 4.5 mg, 0.018 mmol, 6% **4a** (**OAc**); 13.9 mg, 0.0664 mmol, 22% **3**; trace **4b** by <sup>1</sup>H NMR; 10.0 mg, 0.0511 mmol, 10% rsm)

# Average overall yield: 24% 4a (OH), trace 4a (OAc), 24% of 3, trace 4b, 9% RSM



Oxidation of 4a (OH) (42.3 mg, 0.20 mmol, 1.0 equiv.) with 0.5 mol% 1 and 2 equiv. H<sub>2</sub>O<sub>2</sub>:

**Run 1** (4.8 mg, 0.023 mmol, 11% **4b**; 5.5 mg, 0.022 mmol, 11% **4a** (OAc); 29.7 mg, 0.140 mmol, 70% rsm **4a** (OH))

**Run 2** (3.8 mg, 0.018 mmol, 9% **4b**; 7.6 mg, 0.030 mmol, 15% **4a** (**OAc**); 30.3 mg, 0.143 mmol, 72% rsm **4a** (**OH**))

Average yield: 10% imide 4b; 71% hemiaminal 4a (OH); 13% hemiaminal acetate 4a (OAc)

Oxidation of 4a (OH) (42.3 mg, 0.20 mmol, 1.0 equiv.) with 10 mol% 1 and 5 equiv. H<sub>2</sub>O<sub>2</sub>:

**Run 1** (21.4 mg, 0.102 mmol, 51% **4b**; 2.1 mg, 0.0082 mmol, 4% **4a** (OAc); 13% rsm **4a** (OH) by <sup>1</sup>H NMR)

**Run 2** (23.3 mg, 0.111 mmol, 56% **4b**; 4.2 mg, 0.017 mmol, 8% **4a** (OAc); 9% rsm **4a** (OH) by <sup>1</sup>H NMR)

Average yield: 54% imide 4b; 11% hemiaminal 4a (OH); 6% hemiaminal acetate 4a (OAc)





1	4a (OH)	BF3•OEt2 (2)	$AlMe_3(3)$	60	15
2	4a (OH)	BF3•OEt2 (3.3)	$AlMe_3(5)$	64	11
3	4a (OAc)	BF3•OEt2 (2)	$AlMe_3(3)$	86	0
4	4a (OAc)	BF3•OEt2 (3.3)	$AlMe_3(5)$	92	0
5	4a (OH)	DAST(1)	$AlMe_3(3)$	81	0
6	4a (OH)	DAST (1.7)	$AlMe_3(5)$	87	0
7	4a (OAc)	DAST(1)	$AlMe_3(3)$	78	0
8	4a (OAc)	DAST (1.7)	$AlMe_3(5)$	85	0

Entry 1. According to general procedure B for optimization studies, 4a (OH) (21.2 mg, 0.10 mmol, 1.0 equiv.) was methylated using BF<sub>3</sub>• OEt<sub>2</sub> (24.7  $\mu$ L, 0.20 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2 M, 150  $\mu$ L, 0.30 mmol, 3.0 equiv.) as described. Starting material did not fully dissolve and likely contributed to lower conversion.

**Run 1** (12.6 mg, 0.0601 mmol, 60% **3**; 3.1 mg, 0.0146 mmol, 15% rsm)

Entry 2. According to general procedure B for optimization studies, assuming a 60% oxidation yield to mimic reagent equivalences for a one-pot procedure, 4a (OH) (21.2 mg, 0.10 mmol, 1.0 equiv.) was methylated using BF<sub>3</sub>•OEt<sub>2</sub> (40.7  $\mu$ L, 0.33 mmol, 3.3 equiv.) and AlMe<sub>3</sub> (2 M, 250  $\mu$ L, 0.50 mmol, 5.0 equiv.) in 0.5 mL CH<sub>2</sub>Cl<sub>2</sub> as described. Starting material did not fully dissolve and likely contributed to lower conversion.

Run 1 (13.5 mg, 0.0644 mmol, 64% 3; 2.3 mg, 0.0108 mmol, 11% rsm)

Entry 3. According to general procedure B for optimization studies, 4a (OAc) (25.4 mg, 0.10 mmol, 1.0 equiv.) was methylated using BF<sub>3</sub>• OEt<sub>2</sub> (24.7  $\mu$ L, 0.20 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2 M, 150  $\mu$ L, 0.30 mmol, 3.0 equiv.) as described.

Run 1 (18.0 mg, 0.0858 mmol, 86% 3; 0% rsm)

Entry 4. According to general procedure B for optimization studies, assuming a 60% oxidation yield to mimic reagent equivalences for a one-pot procedure, 4a (OAc) (25.4 mg, 0.10 mmol, 1.0 equiv.) was methylated using BF<sub>3</sub>•OEt<sub>2</sub> (40.7  $\mu$ L, 0.33 mmol, 3.3 equiv.) and AlMe<sub>3</sub> (2 M, 250  $\mu$ L, 0.50 mmol, 5.0 equiv.) in 0.5 mL CH<sub>2</sub>Cl<sub>2</sub> as described.

Run 1 (19.4 mg, 0.0924 mmol, 92% 3; 0% rsm)

Entry 5. According to general procedure C for optimization studies, 4a (OH) (21.2 mg, 0.10 mmol, 1.0 equiv.) was methylated using DAST (13.2  $\mu$ L, 0.10 mmol, 1.0 equiv.) and AlMe<sub>3</sub> (2 M, 150  $\mu$ L, 0.30 mmol, 3.0 equiv.) as described.

Run 1 (17.0 mg, 0.0811 mmol, 81% 3; 0% rsm)

Entry 6. According to general procedure C for optimization studies, assuming a 60% oxidation yield to mimic reagent equivalences for a one-pot procedure, 4a (OH) (21.2 mg, 0.10 mmol, 1.0 equiv.) was methylated using DAST (22.4  $\mu$ L, 0.17 mmol, 1.7 equiv.) and AlMe<sub>3</sub> (2 M, 250  $\mu$ L, 0.50 mmol, 5.0 equiv.) in 0.5 mL CH<sub>2</sub>Cl<sub>2</sub> as described.

Run 1 (18.2 mg, 0.0868 mmol, 87% 3; 0% rsm)

Entry 7. According to general procedure C for optimization studies, 4a (OAc) (25.4 mg, 0.10 mmol, 1.0 equiv.) was methylated using DAST (13.2  $\mu$ L, 0.10 mmol, 1.0 equiv.) and AlMe<sub>3</sub> (2 M, 150  $\mu$ L, 0.30 mmol, 3.0 equiv.) as described.

Run 1 (16.4 mg, 0.0782 mmol, 78% 3; 0% rsm)

Entry 8. According to general procedure C for optimization studies, assuming a 60% oxidation yield to mimic reagent equivalences for a one-pot procedure, 4a (OAc) (25.4 mg, 0.10 mmol, 1.0 equiv.) was methylated using DAST (22.4  $\mu$ L, 0.17 mmol, 1.7 equiv.) and AlMe<sub>3</sub> (2 M, 250  $\mu$ L, 0.50 mmol, 5.0 equiv.) in 0.5 mL CH<sub>2</sub>Cl<sub>2</sub> as described.

Run 1 (17.9 mg, 0.0854 mmol, 85% 3; 0% rsm)

All entries suggest mostly similar yields and conversions between stoichiometric and one-pot equivalences of activators and trimethylaluminum. However, the one-pot equivalences produce slightly higher yields and are recommended for carrying out the methylation.

On the conversion of hemiaminal acetate: The hemiaminal acetate of lactam 2 and other heterocyclic cores have been observed to react with BF<sub>3</sub> and DAST to furnish methylated products (vide supra, Table 1); however, with carbamate substrates like **S1**, hemiaminal acetates do not react effectively (Table 1, entry 10, 14% **S3**).

1-(4-chlorophenyl)pyrrolidin-2-one [2]

Prepared according to literature procedures and the NMR data matched those reported<sup>6</sup>.

1-(4-chlorophenyl)-5-hydroxypyrrolidin-2-one [4a (OH)] <u><sup>1</sup>H NMR:</u> (500 MHz, CDCl<sub>3</sub>) δ 7.48 (d, *J* = 8.9 Hz, 2H), 7.34 (d, *J* = 8.9 Hz, 2H), 5.63 (br s, 1H), 3.18 (br s, 1H), 2.83-2.69 (m, 1H), 2.53-2.38 (m, 2H), 2.09-2.00 (m, 1H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.35, 135.86, 131.67, 129.33, 124.50, 85.21, 29.75, 28.38

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>10</sub>H<sub>11</sub>NO<sub>2</sub>Cl [M+H]<sup>+</sup>: 212.0478, found 212.0482.

# 1-(4-chlorophenyl)-5-oxopyrrolidin-2-yl acetate [4a (OAc)]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.38 (d, *J* = 9.0 Hz, 2H), 7.34 (d, *J* = 9.2 Hz, 2H), 6.60 (d, *J* = 5.8 Hz, 1H), 2.87-2.70 (m, 1H),

2.61-2.42 (m, 2H), 2.19-2.10 (m, 1H), 2.05 (s, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.82, 170.36, 135.45, 132.05, 129.41, 124.43, 86.04, 29.41, 26.46, 21.24

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>10</sub>H<sub>9</sub>NOCl [M-Ac]<sup>+</sup>: 194.0373, found 194.0364.

1-(4-Chlorophenyl)-5-methylpyrrolidin-2-one [3]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.37-7.29 (m, 4H), 4.27 (sxt, *J* = 6.1 Hz, 1H), 2.63 (ddd, *J* = 17.2, 9.5, 6.2 Hz, 1H), 2.52 (ddd, *J* = 17.0, 9.5, 7.1 Hz, 1H), 2.36 (ddt, *J* = 13.5, 9.5, 7.2 Hz, 1H), 1.79-1.69 (m, 1H), 1.20 (d, *J* = 6.2 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.29, 136.27, 130.98, 129.16, 125.02, 55.53, 31.36, 26.72, 20.12 HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>11</sub>H<sub>13</sub>NOCl [M+H]<sup>+</sup>: 210.0686, found 210.0686.



# 1-(4-chlorophenyl)pyrrolidine-2,5-dione [4b]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

 $\delta$  7.44 (d, J = 8.8 Hz, 2H), 7.25 (d, J = 8.6 Hz, 2H), 2.89 (s, 4H)

These data matched those reported in the literature<sup>7</sup>.

#### 1-(4-chlorophenyl)-1,5-dihydro-2*H*-pyrrol-2-one [4c]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.68 (d, *J* = 8.9 Hz, 2H), 7.34 (d, *J* = 8.9 Hz, 2H), 7.19 (dt, *J* = 6.1, 2.0 Hz, 1H), 6.28 (dt, *J* = 6.1, 2.0 Hz, 1H), 4.43 (t, *J* = 2.0 Hz, 2H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.21, 142.35, 137.86, 129.40, 129.27, 129.22 120.01, 53.24

These data matched those reported in the literature<sup>8</sup>.



**3-(4-chlorophenyl)oxazolidin-2-one [S1]** In a 100 mL recovery flask were added 2-oxazolidinone (523 mg, 6.0 mmol, 1.2 equiv.), 1-chloro-4-iodobenzene (1.19 g, 5.0 mmol, 1.0 equiv.),  $Pd_2(dba)_3$  (45.8 mg, 0.05 mmol, 0.01 equiv.), XantPhos (86.8 mg, 0.15 mmol, 0.03 equiv.), and potassium phosphate (1.49 g, 7.0 mmol, 1.4 equiv.). A reflux condenser was placed on the flask, and the system was refilled with argon 3x. 1,4-dioxane (30 mL) was then added, and the mixture was refluxed in 100 °C oil bath overnight under nitrogen atmosphere. Upon completion, the reaction was diluted with  $CH_2Cl_2$  and passed through a Celite plug. The resulting solution was condensed in vacuo and purification via flash chromatography yielded the product as a pale yellow powder (818 mg, 4.14 mmol, 83% yield).

<sup>1</sup><u>H NMR:</u> (400 MHz, CHCl<sub>3</sub>)

δ 7.50 (d, *J* = 9.0 Hz, 2H), 7.34 (d, *J* = 9.1 Hz, 2H), 4.50 (dd, *J* = 8.7, 7.2 Hz, 2H), 4.04 (dd, *J* = 8.8, 7.2 Hz, 2H)

These data matched those reported in the literature<sup>49</sup>.



# 3-(4-chlorophenyl)-4-hydroxyoxazolidin-2-one [S2]

<sup>1</sup><u>H NMR:</u> (400 MHz, CD<sub>3</sub>CN)

δ 7.59 (d, *J* = 9.1 Hz, 2H), 7.41 (d, *J* = 9.1 Hz, 2H), 5.79-5.72 (m, 1H), 4.75 (d, *J* = 8.1 Hz, 1H), 4.51 (dd, *J* = 9.9, 6.2 Hz, 1H), 4.15 (dd, *J* = 9.9, 1.8 Hz, 1H)

<sup>13</sup>C NMR: (126 MHz, CD<sub>3</sub>CN)

 $\delta \ 155.71, \ 136.87, \ 130.81, \ 129.81, \ 124.04, \ 81.20, \ 71.31$ 

HRMS: (ESI-TOF MS ES+)

*m/z* calculated for C<sub>9</sub>H<sub>9</sub>NO<sub>3</sub>Cl [M+H]<sup>+</sup>: 214.0271, found 214.0278.



3-(4-chlorophenyl)-2-oxooxazolidin-4-yl acetate [S3]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.44 (d, *J* = 8.9 Hz, 2H), 7.37 (d, *J* = 8.9 Hz, 2H), 6.67 (d, *J* = 5.5 Hz, 1H), 4.64 (dd, *J* = 10.8,

5.7 Hz, 1H), 4.35 (d, *J* = 10.8 Hz, 1H), 2.10 (s, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.45, 154.70, 134.21, 132.04, 129.61, 123.23, 81.54, 68.58, 21.04

HRMS: (ESI-TOF MS ES+)

*m/z* calculated for C<sub>11</sub>H<sub>10</sub>NO<sub>4</sub>ClNa [M+Na]<sup>+</sup>: 278.0196, found 278.0198.

3-(4-chlorophenyl)-4-methyloxazolidin-2-one [7]

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.36 (AB q, *J* = 9.0 Hz, 4H), 4.57 (t, *J* = 8.3 Hz, 1H), 4.53-4.44 (m, 1H), 4.02 (dd, *J* = 8.2, 5.7 Hz, 1H), 1.32 (d, *J* = 6.1 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 155.55, 135.30, 130.56, 129.36, 123.01, 68.75, 52.33, 18.45 <u>HRMS:</u> (ESI-TOF MS ES+) m/z calculated for C<sub>10</sub>H<sub>11</sub>NO<sub>2</sub>Cl [M+H]<sup>+</sup>: 212.0478, found 212.0473.

CI

# 3-(4-chlorophenyl)oxazol-2(3*H*)-one [S4] <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>) $\delta$ 7.53 (d, *J* = 8.9 Hz, 2H), 7.42 (d, *J* = 8.8 Hz, 2H), 6.96 (d, *J* = 2.2 Hz, 1H), 6.92 (d, *J* = 2.2, 1H) <sup>13</sup><u>C NMR:</u> (126 MHz, CDCl<sub>3</sub>) $\delta$ 153.19, 134.16, 132.33, 129.77, 128.96, 122.26, 114.80 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>9</sub>H<sub>7</sub>NO<sub>2</sub>Cl [M+H]<sup>+</sup>: 196.0165, found 196.0170.



#### III. Preparation and characterization of newly reported starting materials for Figure 3

**1-(4-chlorophenyl)piperidin-2-one [S5]** 4-chloroaniline (1.15 g, 9.00 mmol, 1 equiv.) was dissolved in DCM (20 mL) at 0 °C. 5-bromovaleryl chloride (1.2 mL, 9.0 mmol, 1 equiv.) was added dropwise, and a white precipitate was immediately formed. The reaction was stirred at room temperature for two hours, then diluted with brine (20 mL) and extracted with DCM (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The crude yield was 53%. The crude was then dissolved in THF (20 mL) under argon, and cooled to 0 °C. KO<sup>t</sup>Bu (895 mg, 7.98 mmol, 1.01 equiv.) was then added slowly. The reaction was stirred at 0 °C for two hours before being quenched with brine (20 mL) and extracted with EtOAc (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated in vacuo. The combined organic layers were dried with brine (20 mL) and extracted with EtOAc (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated in vacuo. The combined organic layers were dried with brine (20 mL) and extracted with EtOAc (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting oil was purified by flash chromatography (150 mL silica, loaded with DCM, gradient elution 300 mL 0%  $\rightarrow$  400 mL 10%  $\rightarrow$  20%  $\rightarrow$  30%  $\rightarrow$  40%  $\rightarrow$  1.5 L 50%

EtOAc/Hex) to afford 1-(4-chlorophenyl)piperidin-2-one as a white solid in 36% yield (670.4 mg, 3.2 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, CHCl<sub>3</sub>)

δ 7.34 (d, *J* = 8.6 Hz, 2H), 7.19 (d, *J* = 8.7 Hz, 2H), 3.61 (t, *J* = 5.5 Hz, 2H), 2.55 (t, *J* = 6.2 Hz, 2H), 1.98 – 1.88 (m, 4H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.35, 142.13, 132.45, 129.55, 127.81, 51.86, 33.16, 23.81, 21.72 <u>HRMS:</u> (ESI-TOF MS ES+)

*m/z* calculated for C<sub>11</sub>H<sub>13</sub>ClNO [M+H]<sup>+</sup>: 210.0686, found 210.0684



**3-(4-bromophenyl)oxazolidin-2-one [S6]** In a 100 mL recovery flask were added 2-oxazolidinone (523 mg, 6.0 mmol, 1.2 equiv.), 1-bromo-4-iodobenzene (1.41 g, 5.0 mmol, 1.0 equiv.),  $Pd_2(dba)_3$  (45.8 mg, 0.05 mmol, 0.01 equiv.), XantPhos (86.8 mg, 0.15 mmol, 0.03 equiv.), and potassium phosphate (1.49 g, 7.0 mmol, 1.4 equiv.). A reflux condenser was placed on the flask, and the system was refilled with argon 3x. 1,4-dioxane (30 mL) was then added, and the mixture was refluxed in 100 °C oil bath overnight under nitrogen atmosphere. Upon completion, the reaction was diluted with  $CH_2Cl_2$  and passed through a Celite plug. The resulting solution was condensed in vacuo and purification via flash chromatography yielded the product as a pale yellow crystalline solid, which was triturated with diethyl ether (3x5 mL) (1.03 g, 4.24 mmol, 85% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CHCl<sub>3</sub>)

δ 7.48 (d, *J* = 9.1 Hz, 2H), 7.43 (d, *J* = 9.1 Hz, 2H), 4.48 (dd, *J* = 8.7, 7.2 Hz, 2H), 4.03 (dd, *J* = 8.7, 7.3 Hz, 2H)

These data matched those reported in the literature<sup>9</sup>.

**General procedure for nosyl protection:** In a 100 mL recovery flask at room temperature was added the amine (1.0 equiv.), 4-dimethylaminopyridine (DMAP) (0.1 equiv.), and methylene chloride (0.2 M). Triethylamine (Et<sub>3</sub>N) (1.1 equiv.) was then added, followed by 4-nitrobenzenesulfonyl chloride (NsCl) (1.1 equiv.). The reaction was allowed to stir overnight, then quenched with saturated sodium bicarbonate solution. The layers were separated and the aqueous layer was extracted twice with methylene chloride. The combined organic layer was dried over anhydrous magnesium sulfate, filtered, condensed in vacuo, and purified through flash chromatography.

 $\bigcap_{\substack{\mathsf{N} \\ \mathsf{N}\mathsf{S}}}$ 

**1-((4-nitrophenyl)sulfonyl)pyrrolidine [S7]** According to the general procedure for nosyl protection, pyrrolidine (285 mg, 4.0 mmol, 1.0 equiv.) was reacted with DMAP (48.9 mg, 0.4 mmol, 0.1 equiv.), Et<sub>3</sub>N (614  $\mu$ L, 445 mg, 4.4 mmol, 1.1 equiv.), and NsCl (975 mg, 4.4 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (20 mL). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 20% $\rightarrow$ 40% $\rightarrow$ 60% EtOAc/Hex) to afford the product as a light yellow powder (1.00 g, 3.91 mmol, 98% yield). The NMR data matched those reported in the literature<sup>10</sup>.

### <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.38 (d, *J* = 8.9 Hz, 2H), 8.02 (d, *J* = 8.8 Hz, 2H), 3.29 (ddd, *J* = 6.8, 4.4, 2.8 Hz, 4H), 1.86-1.76 (m, 4H)



(*R*)-2-Methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine [S8] According to the general procedure for nosyl protection, (*R*)-2-methylpyrrolidine (250 mg, 2.94 mmol, 1.0 equiv.) was reacted with DMAP (35.7 mg, 0.294 mmol, 0.1 equiv.), Et<sub>3</sub>N (451  $\mu$ L, 327 mg, 3.23 mmol, 1.1 equiv.), and NsCl (717 mg, 3.23 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (14.7 mL). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10% $\rightarrow$ 400 mL 20% EtOAc/Hex) to afford the product as a light yellow powder (653 mg, 2.41 mmol, 89% yield). The spectra data match with 12 (vide infra).

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.37 (d, J = 8.9 Hz, 2H), 8.03 (d, J = 8.9 Hz, 2H), 3.78 (pd, J = 6.5, 4.2 Hz, 1H), 3.49 (ddd, J = 10.4, 7.1, 4.8 Hz, 1H), 3.19 (dt, J = 10.3, 7.4 Hz, 1H), 1.97-1.84 (m, 1H), 1.81-1.70 (m, 1H), 1.67-1.51 (m, 2H), 1.33 (d, J = 6.4 Hz, 3H) [α]<sub>D</sub><sup>24</sup> = -70.4° (c = 1.00, CH<sub>2</sub>Cl<sub>2</sub>)



**2-(4-chlorophenyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine [S10]** In a flame-dried 25-mL recovery flask equipped with a magnetic stir bar were added magnesium (304 mg, 12.5 mmol, 1 equiv.) and small

piece of iodine. Diethyl ether (1 mL) was then added to afford a brown solution. 1-Chloro-4-iodobenzene (2.4 g, 12.5 mmol, 1 equiv.) dissolved in Et<sub>2</sub>O (1 mL) was then added dropwise. The reaction was allowed to stir at room temperature for 30 min. 4-chlorobutanenitrile (1.2 mL, 1.3 g, 12.5 mmol, 1 equiv.) was dissolved in Et<sub>2</sub>O (1.2 mL) and added to the freshly prepared Grignard reagent. The resulting mixture was refluxed for 1 h; upon which diethyl ether was removed through distillation while xylene (12.5 mL) was added to the flask. The resulting mixture was then refluxed overnight. Upon completion, the reaction mixture was partitioned between ethyl acetate and NH<sub>4</sub>Cl solution, and the aqueous layer extracted with EtOAc (2x10 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flash chromatography afforded 5-(4-chlorophenyl)-3,4-dihydro-2H-pyrrole S9 as a yellow powder (922 mg, 5.13 mmol, 41% yield), <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>):  $\delta$  7.77 (d, J = 8.6 Hz, 2H), 7.38 (d, J = 8.6 Hz, 2H), 4.06 (dd, J = 7.5, 2.0 Hz, 2H), 2.97-2.87 (m, 2H), 2.10-2.00 (m, 2H). In a 100-mL recovery flask was added **S9** (922 mg, 5.13 mmol, 1 equiv.), MeOH (6.1 mL), and AcOH (1.5 mL). The reaction mixture was cooled to -36 °C, and sodium borohydride (433 mg, 11.4 mmol, 2.23 equiv.) was added slowly in one portion. The solution was then allowed to warm up to room temperature and stirred for 2 h. The solvents were removed in vacuo and water was added. The mixture was partitioned between 1 M NaOH and CH<sub>2</sub>Cl<sub>2</sub>, and the aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3x10 mL). The organic layers were combined, dried over  $K_2CO_3$ , and condensed in vacuo. According to the general procedure for nosyl protection, the crude was directly reacted with DMAP (62.7 mg, 0.513 mmol, 0.1 equiv.), Et<sub>3</sub>N (787 µL, 571 mg, 5.64 mmol, 1.1 equiv.), and NsCl (1.25 g, 5.64 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (25 mL). Following workup, the crude material was purified by flash chromatography (75 mL silica, gradient elution 100 mL  $0\% \rightarrow 200 \text{ mL } 10\% \rightarrow 400 \text{ mL } 50\%$  EtOAc/Hex) to afford the product as a light yellow powder (787 mg, 2.15 mmol, 42% yield).

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.31 (d, *J* = 8.9 Hz, 2H), 7.87 (d, *J* = 8.8 Hz, 2H), 7.25 (d, *J* = 7.8 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 4.81 (dd, *J* = 7.9, 4.1 Hz, 1H), 3.65 (ddd, *J* = 9.7, 6.9, 5.0 Hz, 1H), 3.53 (dt, *J* = 9.9, 7.0 Hz, 1H), 2.18-2.05 (m, 1H), 2.02-1.89 (m, 1H), 1.89-1.74 (m, 2H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.10, 144.34, 140.70, 133.49, 128.76, 128.54, 127.79, 124.33, 63.25, 49.64, 36.08, 24.28 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>16</sub>ClN<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 367.0519, found 367.0524.



**Methyl ((4-nitrophenyl)sulfonyl)-***L***-prolinate [S11]** Synthesized using a previously reported synthesis and the NMR data matched those reported<sup>5</sup>.



(*S*)-1-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)ethan-1-one [S12] In a 100-mL recovery flask containing *tert*-butyl (*S*)-2-acetylpyrrolidine-1-carboxylate<sup>11</sup> (1.05 g, 4.93 mmol, 1 equiv.) were added CH<sub>2</sub>Cl<sub>2</sub> (10 mL) and trifluoroacetic acid (1.9 mL, 24.7 mmol, 5 equiv.). The mixture was stirred overnight, concentrated, redissolved in CH<sub>2</sub>Cl<sub>2</sub> (10 mL), and washed with NaOH (1M, 5 mL). The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. According to the general procedure for nosyl protection, the crude was directly reacted with DMAP (60.2 mg, 0.493 mmol, 0.1 equiv.), Et<sub>3</sub>N (756 µL, 548 mg, 5.42 mmol, 1.1 equiv.), and NsCl (1.20 g, 5.42 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL). Following workup, the crude material was purified thrice by flash chromatography (50 mL silica, 400 mL 40% EtOAc/Hex) to afford the product as a light yellow powder (203 mg, 0.68 mmol, 14% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.00 (d, *J* = 8.8 Hz, 2H), 4.20 (dd, *J* = 8.7, 4.7 Hz, 1H), 3.48 (dt, *J* = 9.6, 6.5 Hz, 1H), 3.34 (dt, *J* = 9.7, 6.8 Hz, 1H), 2.26 (s, 3H), 2.06-1.95 (m, 1H), 1.95-1.79 (m, 2H), 1.78-1.64 (m, 1H)

### <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 206.69, 150.39, 143.66, 128.96, 124.48, 67.65, 49.06, 29.82, 26.48, 24.90 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 329.0807, found 329.0804. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -71.4° (c = 0.72, CH<sub>2</sub>Cl<sub>2</sub>)



(*S*)-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methyl acetate [S13] According to the general procedure for nosyl protection, L-prolinol (425 mg, 4.20 mmol, 1 equiv.) was reacted with DMAP (51.3 mg, 0.420 mmol, 0.1 equiv.), Et<sub>3</sub>N (644  $\mu$ L, 467 mg, 4.62 mmol, 1.1 equiv.), and NsCl (1.02 g, 4.62 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elusion 300 mL 30% $\rightarrow$ 50% EtOAc/Hex) to afford (*S*)-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methanol as a mixture with byproducts (roughly 1.01 g, 3.53 mmol). The crude was transferred to a 100-mL recovery flask, where DMAP (43.1 mg, 0.353 mmol, 0.1 equiv.),

CH<sub>2</sub>Cl<sub>2</sub> (7 mL), Et<sub>3</sub>N (1.48 mL, 1.07 g, 10.6 mmol, 3 equiv.), and Ac<sub>2</sub>O (1.67 mL, 1.80 g, 17.7 mmol, 5 equiv.) were added in order. The mixture was stirred overnight, and partitioned between saturated NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flash chromatography (50 mL silica, gradient elusion 200 mL 20% $\rightarrow$ 30% $\rightarrow$ 40% EtOAc/Hex) afforded the product as a white powder (1.14 g, 3.48 mmol, 83% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.38 (d, *J* = 8.9 Hz, 2H), 8.04 (d, *J* = 8.9 Hz, 2H), 4.21 (dd, *J* = 11.2, 4.9 Hz, 1H), 4.13 (dd, *J* = 11.1, 6.9 Hz, 1H), 3.97-3.90 (m, 1H), 3.50 (ddd, *J* = 10.5, 7.2, 4.0 Hz, 1H), 3.24-3.17 (m, 1H), 2.07 (s, 3H), 1.98-1.86 (m, 1H), 1.82-1.74 (m, 1H), 1.72-1.62 (m, 2H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.79, 150.33, 143.57, 128.80, 124.54, 65.89, 58.37, 49.44, 28.86, 24.18, 21.01 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 329.0807, found 329.0804. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -87.5° (c = 0.99, CH<sub>2</sub>Cl<sub>2</sub>)

(*S*)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonitrile [S14] According to literature<sup>12</sup>, in a 250-mL round-bottom flask were added ((4-nitrophenyl)sulfonyl)-*L*-proline<sup>5</sup> (4.53 g, 15.1 mmol, 1 equiv.), THF (20 mL), Et<sub>3</sub>N (2.1 mL, 1.53 g, 15.1 mmol, 1 equiv.), and ethyl carbonochloridate (1.44 mL, 1.64 g, 15.1 mmol, 1 equiv.). The reaction mixture was stirred for 20 min, upon which NH<sub>4</sub>OH (30 wt%, 1 mL, 17.6 mmol, 1.17 equiv.) was added. The reaction was then stirred overnight. Upon completion, the solvent was removed in vacuo and the crude redissolved in CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was washed with sat. NaHCO<sub>3</sub> and isolated, dried over MgSO<sub>4</sub>, and condensed in vacuo. THF (80 mL) and Et<sub>3</sub>N (6.3 mL, 4.58 g, 45.3 mmol, 3 equiv.) were then added, followed by TFAA (3.2 mL, 4.76 g, 22.7 mmol, 1.5 equiv.). The reaction mixture was stirred for 3 h, and then quenched with water. The solvent was removed in vacuo and the residue redissolved in CH<sub>2</sub>Cl<sub>2</sub>, washed with 10% citric acid, brine, and sat. NaHCO<sub>3</sub>. Purification by flash chromatography (50 mL silica, gradient elusion 200 mL 20% $\rightarrow$ 40% $\rightarrow$ 60% $\rightarrow$ 80% $\rightarrow$ 100% EtOAc/Hex) and recrystallization (80 mL methanol, 45 mL hexanes) afforded the product as a yellow crystalline solid (2.50 g, 8.89 mmol, 59% yiel).

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.41 (d, *J* = 8.8 Hz, 2H), 8.12 (d, *J* = 8.8 Hz, 2H), 4.74 (dd, *J* = 6.2, 4.3 Hz, 1H), 3.56 (dd, *J* = 9.1, 7.7 Hz, 1H), 3.35 (ddd, *J* = 9.3, 6.9, 5.0 Hz, 1H), 2.35-2.23 (m, 2H), 2.19-2.07 (m, 2H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.65, 143.56, 128.89, 124.69, 117.38, 48.80, 47.64, 32.04, 24.90 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>11</sub>H<sub>12</sub>N<sub>3</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 282.0549, found 282.0556.

 $[\alpha]_{D}^{24} = -93.5^{\circ} (c = 1.11, CH_2Cl_2)$ 



**1-((4-nitrophenyl)sulfonyl)-3-phenylpyrrolidine [S15]** According to the general procedure for nosyl protection, 3-phenylpyrrolidine (294 mg, 2.00 mmol, 1.0 equiv.) was reacted with  $Et_3N$  (307  $\mu$ L, 223 mg, 2.20 mmol, 1.1 equiv.), and NsCl (488 mg, 2.20 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL). Following workup, the crude material was purified by flash chromatography (50 mL silica, 200 mL 20% EtOAc/Hex) to afford the product as a yellow powder (613 mg, 1.84 mmol, 92% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.39 (d, *J* = 8.6 Hz, 2H), 8.03 (d, *J* = 8.6 Hz, 2H), 7.34-7.19 (m, 3H), 7.10 (d, *J* = 7.2 Hz, 2H), 3.78 (dt, *J* = 6.8, 2.0 Hz, 1H), 3.58 (ddd, *J* = 9.8, 8.8, 3.3 Hz, 1H), 3.46-3.38 (m, 1H), 3.35-3.27 (m, 1H), 3.26 (t, *J* = 7.7 Hz, 1H), 2.27 (ddd, *J* = 13.1, 6.7, 3.2 Hz, 1H), 1.96 (dq, *J* = 12.6, 9.1 Hz, 1H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.26, 143.25, 139.97, 128.92, 128.62, 127.38, 126.98, 124.54, 54.35, 48.07, 44.02, 32.86 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>17</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 333.0909, found 333.0898.



Methyl (*S*)-1-((4-(methoxycarbonyl)phenyl)sulfonyl)piperidine-2-carboxylate [S16] *L*-Homoproline (258.32 mg, 2.0 mmol, 1 equiv.) was dissolved in dry MeOH (0.1M) under N<sub>2</sub> and cooled to 0 °C. SOCl<sub>2</sub> (1.0 mL, 14 mmol, 7 equiv.) was added dropwise. The ice bath was removed and the reaction was stirred at room temperature overnight. It was then azeotroped under vacuum with methanol. The resulting yellow solid was then dissolved in DCM (0.1M), and DMAP (24 mg, 0.2 mmol, 0.1 equiv.) and triethylamine

(613 µL, 4.4 mmol, 2.2 equiv.) were added respectively. Methyl 4-(chlorosulfonyl)benzoate (704 mg, 3 mmol, 1.5 equiv.) was added slowly and the resulting amber solution was stirred at room temperature overnight. The dark brown solution was then diluted with DCM and NaHCO<sub>3</sub>, and the aqueous layer was extracted with DCM three times. The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated in vacuo. The resulting yellow oil was purified by flash chromatography (75 mL silica, loaded with DCM, mL 20% gradient elution 800 EtOAc/Hex) afford methyl *(S)*-1-*((*4to (methoxycarbonyl)phenyl)sulfonyl)piperidine-2-carboxylate as a yellow solid in 98% yield (666 mg, 1.95 mmol).

#### <sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.12 (d, *J* = 8.6 Hz, 2H), 7.82 (d, *J* = 8.5 Hz, 2H), 4.74 (d, J = 4.4, 1H), 3.92 (s, 3H), 3.79 (d, J = 11.2 Hz, 1H), 3.49 (s, 3H), 3.16 (td, *J* = 12.8, 2.9 Hz, 1H), 2.11 (d, J = 10.8 Hz, 1H), 1.76 – 1.69 (m, 1H), 1.68-1.60 (m, 2H), 1.46 (dddd, *J* = 17.8, 8.3, 7.1, 4.0 Hz, 1H), 1.23 (qt, J = 14.11, 3.70 Hz, 1H).

# <sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 170.91, 165.77, 143.97, 133.58, 130.08, 127.19, 55.26, 52.64, 52.09, 42.89, 27.89, 24.80, 20.07. <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>15</sub>H<sub>19</sub>NaNO<sub>6</sub>S [M+Na]<sup>+</sup>: 364.0831, found 364.0820.

 $[]_{D}^{24} = -28.7 (c = 1.00, EtOH)$ 

,OAc

(*S*)-(1-((4-nitrophenyl)sulfonyl)piperidin-2-yl)methyl acetate [S17] (*S*)-piperidin-2-ylmethanol (760 mg, 6.6 mmol, 1 equiv.) was dissolved in DCM (0.1 M) at 0 °C. Triethylamine (966 µL, 6.93 mmol, 1.05) was added dropwise. Nosyl chloride (1.54 g, 6.92 mmol, 1.05 equiv.) was added portion-wise. The reaction was brought to RT and stirred overnight. It was then diluted with NaHCO<sub>3</sub> (15 mL), and the aqueous layer was extracted three times (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting oil was purified by flash chromatography (100 mL silica, DCM loaded, gradient elution 300 mL 0%  $\rightarrow$  20%  $\rightarrow$  30%  $\rightarrow$  50% EtOAc/Hex) to afford the desired product as an oil in 37% yield (733 mg, 2.44 mmol). The resulting alcohol was dissolved in DCM (20 mL) and acetic anhydride (1.2 mL, 12.2 mmol, 5 equiv.) was added followed by triethylamine (690 µL, 4.88 mmol, 2 equiv.). The solution was stirred overnight at RT before being diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted three times (3 x 10 mL). The combined organic layers were dried with NaHCO<sub>3</sub> (15 mL). The solution was stirred overnight at RT before being diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted three times (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting oil was purified by flash chromatography (15 mL).

(100 mL silica, DCM loaded, gradient elution 300 mL  $0\% \rightarrow 10\% \rightarrow 20\% \rightarrow 30\%$  EtOAc/Hex) to afford the desired product as white solid in 72% yield (600 mg, 1.75 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.34 (d, *J* = 8.7 Hz, 2H), 8.03 (d, *J* = 8.7 Hz, 2H), 4.41 – 4.26 (m, 2H), 4.08 (dd, *J* = 10.7, 5.3 Hz, 1H), 3.78 (dd, *J* = 14.5, 5.2 Hz, 1H), 3.12 (td, *J* = 13.9, 2.6 Hz, 1H), 2.02 (s, 3H), 1.69 – 1.64 (m, 1H), 1.62 – 1.55 (m, 2H), 1.53 – 1.43 (m, 2H), 1.31 – 1.17 (m, 1H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 171.06, 150.17, 147.75, 128.41, 124.72, 61.38, 51.88, 41.75, 25.74, 24.89, 21.19, 19.09. <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>14</sub>H<sub>19</sub>N<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 343.0964, found 343.0974.

 $[]_{D}^{24} = -22.5 (c = 1.00, EtOH)$ 



6-fluoro-3-(1-((4-nitrophenyl)sulfonyl)piperidin-4-yl)benzo[d]isoxazole [S18] 6-Fluoro-3-(4piperidinyl)benzisoxazole hydrochloride (2.05 g, 8.00 mmol, 1 equiv.) was dissolved in DCM (15 mL, 0.5 M). DMAP (90 mg, 0.80 mmol, 0.1 equiv.), triethylamine (3.3 mL, 24 mmol, 3 equiv.) and nosyl chloride (3.5 g, 16 mmol, 2 equiv.) were added respectively. The solution was stirred for 12 hours before being diluted with 1 M NaOH (10 mL). The aqueous layer was extracted with DCM (3x15 mL), and the combined organics were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting brown oil was purified by flash chromatography (200 mL silica, DCM loaded, gradient elution 200 mL 0%  $\rightarrow$  300 mL 15%  $\rightarrow$  20%  $\rightarrow$  30%  $\rightarrow$  40% EtOAc/Hex  $\rightarrow$  1.6 L EtOAc) to afford the desired product as a yellow powder in 77% yield (2.50 g, 6.17 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.41 (d, *J* = 8.8 Hz, 2H), 7.99 (d, *J* = 8.8 Hz, 2H), 7.57 (dd, *J* = 8.7, 5.0 Hz, 1H), 7.25 (dd, *J* = 5.2, 1.6 Hz 1H), 7.07 (td, *J* = 8.8, 2.2 Hz, 1H), 3.88 (dt, *J* = 11.9, 3.8 Hz, 2H), 3.12 (tt, *J* = 9.8, 5.1 Hz, 1H), 2.73 (ddd, *J* = 12.1, 9.6, 4.2 Hz, 2H), 2.34 – 2.07 (m, 4H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 164.36 (d, *J* = 251.7 Hz), 164.10 (d, *J* = 13.6 Hz), 159.71, 150.40, 142.65, 128.91, 124.58, 122.13 (d, *J* = 11.1 Hz), 116.98, 112.94 (d, *J* = 25.1 Hz), 97.81 (d, *J* = 26.8 Hz), 45.86, 33.22, 29.68

<sup>19</sup>F NMR: (471 MHz, Chloroform-*d*)

#### $\delta$ -108.69 (td, J = 8.6, 5.1 Hz)

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>17</sub>FN<sub>3</sub>O<sub>5</sub>S [M+H]<sup>+</sup>: 406.0873; found 406.0870.



4-(4-bromophenyl)-1-(phenylsulfonyl)piperidine [S19] 4-(4-bromophenyl)piperidine•HCl (304.3mg, 1.100 mmol, 1.0 equiv.) was dissolved in DCM (5 mL, 0.2 M) at rt. DMAP (13.4 mg, 0.110 mmol, 0.1 equiv.), triethylamine (337 µL, 2.42 mmol, 2.20 equiv.) and benzenesulfonyl chloride (281 µL, 2.20 mmol, 2.00 equiv.) were added respectively. The solution was stirred for 12 hours and then diluted with sat. NaHCO<sub>3</sub> (10 mL). The aqueous layer was extracted three times with DCM (3x10 mL), and the combined organics were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting yellow oil was purified by flash chromatography (75 mL silica, DCM loaded, gradient elution 200 mL 0% → 7.5% → 10% → 12% EtOAc/Hex) to afford the desired product as a lightly yellow powder in 83% yield (347 mg, .913 mmol).

#### <sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.80 (d, *J* = 8.0 Hz, 2H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.56 (t, *J* = 7.6 Hz, 2H), 7.41 (d, *J* = 8.3 Hz, 2H), 7.01 (d, *J* = 8.3 Hz, 2H), 3.95 (d, *J* = 11.7 Hz, 2H), 2.43-2.33 (m, 3H), 1.91 – 1.71 (m, 4H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-d)

δ 143.92, 136.39, 132.88, 131.80, 129.17, 128.56, 127.81, 120.42, 46.84, 41.45, 32.57. <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>19</sub>BrNO<sub>2</sub>S [M+H]<sup>+</sup>: 380.0320, found 380.0309.

### Ns N —

**1-((4-nitrophenyl)sulfonyl)azepane [S20]** Azepane (451  $\mu$ L, 4 mmol, 1.0 equiv.) was dissolved in DCM (0.4 M). DMAP (49mg, 0.4 mmol, 0.1 equiv.), NEt<sub>3</sub> (1.1 mL, 8 mmol, 2 equiv.) and nosyl chloride (1.77 g, 8 mmol, 2 equiv.) were added respectively and stirred at room temperature overnight. The resulting brown solution was diluted with NaHCO<sub>3</sub> (15 mL), and the aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The resulting

oil was purified by column chromatography (100 mL silica, DCM loaded, 200 mL  $0\% \rightarrow 300$  mL  $5\% \rightarrow 10\% \rightarrow 20\% \rightarrow 600$  mL 50% ethyl acetate in hexanes) to afford 1-((4-nitrophenyl)sulfonyl)azepane as a white powder in 99% yield (1.13 g, 3.96 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.35 (d, *J* = 8.8 Hz, 2H), 7.97 (d, *J* = 8.8 Hz, 2H), 3.31 (d, *J* = 4.8 Hz, 4H), 1.78-1.68 (m, 4H), 1.65-1.56 (m, 4H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 149.96, 145.65, 128.17, 124.46, 48.55, 29.29, 26.97.

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>17</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 285.0909, found 285.0912.



**3-((4-nitrophenyl)sulfonyl)-3-azabicyclo[3.1.1]heptane [S21]** 3-azabicyclo[3.1.1]heptane•HCl (270 mg, 2 mmol, 1 equiv.) was dissolved in DCM (0.4 M). NEt<sub>3</sub> (836µL, 6 mmol, 3 equiv.) and nosyl chloride (886 mg, 4 mmol, 2 equiv.) were added respectively and stirred at room temperature overnight. The resulting brown solution was diluted with DCM (20 mL) and NaHCO<sub>3</sub> (15 mL), and the aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The resulting oil was purified by column chromatography (100 mL silica, DCM loaded, 200 mL 0%  $\rightarrow$  300 mL 10%  $\rightarrow$  20%  $\rightarrow$  20% ethyl acetate in hexanes) to afford 3-((4-nitrophenyl)sulfonyl)-3-azabicyclo[3.1.1]heptane as a pale yellow powder in 98% yield (558 mg, 1.96 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.38 (d, *J* = 8.9 Hz, 2H), 8.02 (d, *J* = 8.8 Hz, 2H), 3.56 (s, 4H), 2.44 (tt, *J* = 6.3, 1.4 Hz, 2H), 2.10 (qt, *J* = 7.8, 3.9 Hz, 2H), 1.17 (dt, *J* = 7.9, 3.9 Hz, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 150.31, 143.87, 128.69, 124.64, 51.56, 32.34, 31.42.

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>15</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 283.0753, found 283.0757.



**trans-1-((4-nitrophenyl)sulfonyl)decahydroquinoline [(±)-S22]** *Trans*-decahydroquinoline (696 mg, 5 mmol, 1 equiv.) was dissolved in DCM (15 mL, 0.33M). Triethylamine (1.05 mL, 7.50 mmol, 1.5 equiv.), DMAP (61 mg, 0.5 mmol, 0.1 equiv.) and nosyl chloride (2.2 g, 10 mmol, 2 equiv.) were added respectively. The solution was stirred for 12 hours, and the resulting brown solution was quenched with NaHCO<sub>3</sub> (10 mL). The aqueous layer was extracted with DCM (3 x 10 mL), and the organic layers were combined, dried with Na<sub>2</sub>SO<sub>3</sub>, and concentrated *in vacuo*. The resulting oil was purified by flash chromatography (200 mL silica, DCM loaded, gradient elution 200 mL 0%  $\rightarrow$  400 mL 10%  $\rightarrow$  15%  $\rightarrow$  15% EtOAc/Hex) to afford the desired product as a white powder in 83% yield (1.35 g, 4.16 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.34 (d, *J* = 8.8 Hz, 2H), 7.98 (d, *J* = 8.6 Hz, 2H), 4.13 (dtd, *J* = 12.9, 4.3, 1.4 Hz, 1H), 2.95 – 2.80 (m, 1H), 2.65 (dt, *J* = 8.7, 2.8 Hz, 1H), 2.10 – 2.00 (m, 1H), 1.80-1.58 (m, 7H), 1.54 – 1.41 (m, 1H), 1.29 – 1.09 (m, 2H), 1.08 – 0.88 (m, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 149.88, 147.61, 128.32, 124.39, 65.70, 48.84, 41.02, 33.48, 31.69, 31.59, 26.06, 25.54, 25.41. <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>15</sub>H<sub>21</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 325.1222, found 325.1227.

# Br

**6-bromo-2-((4-nitrophenyl)sulfonyl)-1,2,3,4-tetrahydroisoquinoline** [S23] 6-Bromo-1,2,3,4-tetrahydroisoquinoline hydrochloride (373 mg, 1.50 mmol, 1 equiv.) was dissolved in DCM (5 mL, 0.3M). DMAP (18 mg, 0.15, 0.1 equiv.), triethylamine (627  $\mu$ L, 4.50 mmol, 3 equiv.) and nosyl chloride (665 mg, 3.00 mmol, 2 equiv.) were added respectively. The solution was stirred for 12 hours before being diluted with sat. NaHCO<sub>3</sub> (10 mL). The aqueous layer was extracted with DCM (3x10 mL), and the combined organic layers were dried with Na<sub>2</sub>CO<sub>3</sub> and concentrated *in vacuo*. The resulting yellow oil was purified by flash chromatography (100 mL silica, DCM loaded, gradient elution 200 mL 0%  $\rightarrow$  300 mL 15%  $\rightarrow$  25%  $\rightarrow$  60% EtOAc/Hex) to afford the desired product as a pale yellow solid in 81% yield (486.6 mg, 1.22 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.38 (d, *J* = 8.1 Hz, 2H), 8.02 (d, *J* = 8.1 Hz, 2H), 7.30 (d, *J* = 8.4 Hz, 1H), 7.26 (s, 1H), 6.92 (d, *J* = 8.2 Hz, 1H), 4.29 (s, 2H), 3.45 (t, *J* = 5.9 Hz, 2H), 2.91 (t, *J* = 6.0 Hz, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 150.40, 142.99, 135.11, 131.93, 130.07, 129.95, 128.85, 128.01, 124.59, 120.95, 47.17, 43.48, 28.62.

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>15</sub>H<sub>14</sub>BrN<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 396.9858, found 396.9710.



(methyl (S)-2-((4-bromophenyl)sulfonyl)-1,2,3,4-tetrahydroisoquinoline-3-carboxylate [S24] (S)-1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid (532 mg, 3 mmol, 1equiv.) was dissolved in dry MeOH (0.1 M) under N2 and cooled to 0 °C. SOCl2 (1.5 mL, 21 mmol, 7 equiv.) was added dropwise. The ice bath was removed and the reaction was stirred at room temperature overnight. It was then azeotroped under vacuum with methanol. The resulting yellow solid was then dissolved in DCM (0.1 M), and DMAP (37 mg, 0.3 mmol, 0.1 equiv.) and triethylamine (1.25 mL, 9 mmol, 3 equiv.) were added respectively. 4bromo-benzenesulfonyl chloride (1.53g, 6 mmol, 2 equiv.) was added slowly and the resulting yellow solution was stirred at room temperature overnight. The dark brown solution was then diluted NaHCO<sub>3</sub> (20 mL), and the aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting brown oil was purified with column chromatography (100 mL silica, loaded with DCM, 150 mL 0%  $\rightarrow$  300 mL 10%  $\rightarrow$  15%  $\rightarrow$  25% ethyl afford (S)-2-((4-bromophenyl)sulfonyl)-1,2,3,4acetate in hexanes) to methvl (methyl tetrahydroisoquinoline-3-carboxylate as a yellow oil in 90% yield (1.1g, 2.7 mmol).

# <sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.71 (d, *J* = 8.7 Hz, 2H), 7.63 (d, *J* = 8.6 Hz, 2H), 7.16 (tt, *J* = 7.3, 5.6 Hz, 2H), 7.09 (dd, *J* = 7.2, 1.7 Hz, 1H), 7.03 (dd, *J* = 7.5, 1.6 Hz, 1H), 5.01 (t, *J* = 4.6 Hz, 1H), 4.71 (d, *J* = 15.3 Hz, 1H), 4.47 (d, *J* = 15.4 Hz, 1H), 3.47 (s, 3H), 3.21 (d, *J* = 4.5 Hz, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 170.62, 138.19, 132.32, 131.22, 130.69, 129.03, 128.95, 127.86, 127.14, 127.08, 126.26, 54.09, 52.48, 44.58, 32.04.

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>17</sub>BrNO<sub>4</sub>S [M+H]<sup>+</sup>: 410.0062, found 409.9981  $[\alpha]_D^{24} = -15.4$  (c = 1.00, EtOH)



**6,8-dibromoisochromane** [**S25**] 3,5-dibromo-benzeneacetic acid (1.18 g, 4.01 mmol, 1 equiv.) was dissolved in THF (20 mL) under argon at 0 °C. BH<sub>3</sub>•THF (2M solution, 8 mL, 8 mmol, 2 equiv.) was added dropwise. The ice bath was removed and the reaction stirred for 4 hours before being guenched with brine (15 mL). The aqueous layer was extracted with EtOAc (3 x 10 mL), and the combined organic layers were dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo*. The resulting oil was dissolved in DCM (20 mL) and DIPEA (2.1 mL, 12 mmol, 3 equiv.) was added dropwise. MEMCl (913 µL, 8 mmol, 2 equiv.) was added dropwise. The solution was stirred overnight before being diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted with DCM (3 x 10 mL), dried with Na<sub>2</sub>SO<sub>4</sub>, and concentrated *in vacuo*. The resulting oil was purified by column chromatography (150 mL silica, DCM loaded, 400 mL  $0\% \rightarrow 10\%$ 15%  $\rightarrow$ 20% afford  $\rightarrow$ ethyl acetate in hexanes) to 1,3-dibromo-5-(2-((2methoxyethoxy)methoxy)ethyl)benzene as an oil in 61% yield (900 mg, 2.44 mmol). The MEM protected alcohol was dissolved in DCM (20 mL) under argon at 0 °C. TiCl<sub>4</sub> (439 µL, 4 mmol, 2 equiv.) was added dropwise at 0 °C and the reaction was stirred for 5 hours at 0 °C. It was diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted with DCM (3 x 10 mL), and the combined organic layers were dried with  $Na_2SO_4$  and concentrated *in vacuo*. The resulting oil was purified by column chromatography (75) mL silica, loaded with 10% EtOAc/Hexanes, 300 mL  $0\% \rightarrow 5\% \rightarrow 10\%$  ethyl acetate in hexanes) to afford the desired isochroman in 74% yield as a white powder (531 mg, 1.81 mmol).

### <sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.53 (s, 1H), 7.24 (s, 1H), 4.63 (s, 2H), 3.90 (t, J = 5.6 Hz, 2H), 2.82 (t, J = 5.6 Hz, 2H). <sup>13</sup>C NMR: (126 MHz, Chloroform-d)

δ 138.15, 133.50, 132.69, 131.20, 121.56, 120.48, 68.70, 64.83, 28.45.

# HRMS: (ESI TOF MS ES+)

*m*/*z* calculated for C<sub>9</sub>H<sub>9</sub>Br<sub>2</sub>O [M+H]<sup>+</sup>: 290.9020, found 290.8856.

#### **IV. Experimental procedures and compound characterization for Figure 3**

**General procedure for C–H oxidation:** To a 40 mL vial equipped with a stir bar were added the substrate (0.30 mmol, 1.0 equiv,), (*S*,*S*)-Mn(CF<sub>3</sub>PDP) **1** (2.0 mg, 0.0015 mmol, 0.005 equiv.), MeCN (0.6 mL, 0.5 M), and AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.). For achiral or racemic substrates, (*R*,*R*)- and (*S*,*S*)-**1** can be used interchangeably. The reaction mixture was then placed into a -36 °C dry ice/1,2-dichloroethane bath. A 10 mL syringe was charged with a solution of H<sub>2</sub>O<sub>2</sub> (85.2  $\mu$ L, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). The syringe was then fitted with a 25G needle and the solution was slowly added into the stirring reaction mixture via a syringe pump at 3.75 mL/h. Upon completion, the vial was taken from the cold bath, and the reaction mixture was immediately loaded onto a 15 mL silica plug. Ethyl acetate was used to rinse the vial (2x1 mL), and the resulting washes were also loaded onto the silica plug. The plug was allowed to sit for five minutes in order to decompose any remaining hydrogen peroxide as well as absorbing the reaction mixture. Ethyl acetate (150 mL) was then allowed to pass through the plug, and the eluent was concentrated in vacuo, transferred into a 25 mL recovery flask, condensed and placed on vacuum overnight to remove the residual acetic acid.

General procedure for BF<sub>3</sub>-promoted methylation: The crude from oxidation was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL, 0.2 M), backfilled with nitrogen 3x, and placed into a -78 °C dry ice/acetone bath. Trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) was then added dropwise, followed by boron trifluoride diethyl etherate (74.0  $\mu$ L, 0.60 mmol, 2.0 equiv.). The reaction mixture was stirred at -78 °C for 1 h, then allowed to warm to room temperature while stirring for 3 h. Upon completion, the reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and poured into a 60 mL separatory funnel containing 3 mL 1 M NaOH for quenching. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over anhydrous MgSO<sub>4</sub>, filtered, and condensed in vacuo before subjecting to purification via flash or medium pressure chromatography.

General procedure for DAST-promoted methylation: The crude from oxidation was dissolved in  $CH_2Cl_2$  (1.5 mL, 0.2 M), backfilled with nitrogen 3x, and placed into a -78 °C dry ice/acetone bath. Diethylaminosulfur trifluoride (39.6 µL, 48.3 mg, 0.30 mmol, 1.0 equiv.) or Deoxo-Fluor (55.3 µL, 66.4 mg, 0.30 mmol, 1.0 equiv.) was added, and the reaction was allowed to warm to room temperature while stirring for 1 h. The reaction was then placed back into -78 °C cold bath, where trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.) was then added dropwise. The reaction mixture was stirred at -78 °C for 2 h, then allowed to warm to room temperature while stirring for 1 h. Upon completion, the reaction was diluted with  $CH_2Cl_2$  (5 mL) and poured into a 60 mL separatory funnel containing 3 mL 1 M NaOH for quenching. The aqueous layer was extracted with  $CH_2Cl_2$  (2x5 mL). The organic layers were

combined, dried over anhydrous MgSO<sub>4</sub>, filtered, and condensed in vacuo before subjecting to purification via flash or medium pressure chromatography.

1-(4-Chlorophenyl)-5-methylpyrrolidin-2-one [3] Gram scale: Following the general oxidation and DAST-promoted procedures, 1-(4-chlorophenyl)pyrrolidin-2-one 2 (1.0 g, 5.11 mmol, 1.0 equiv.) in MeCN (10.2 mL) in a 100 mL round-bottom flask was oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (34.6 mg, 0.0256 mmol, 0.005 equiv.), acetic acid (4.38 mL, 76.7 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (581 µL, 10.2 mmol, 2.0 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN (60 mL, in 50 mL HSW syringe). Following oxidation, the solution was passed through 100 mL silica and flushed with 1 L of EtOAc. The solution was concentrated *in vacuo* and transferred to a 100 mL round bottom flask and left on a high vacuum pump overnight. The crude was then dissolved in 25.6 mL of CH<sub>2</sub>Cl<sub>2</sub> under nitrogen and placed in a dry ice/acetone cold bath. DAST (675 µL, 5.11 mmol, 1.0 equiv.) was added and the solution was stirred for an hour. AlMe<sub>3</sub> (7.67 mL, 15.3 mmol, 3.0 equiv.) was then added slowly. The reaction was stirred at -78°C for two hours before removing the dry ice bath and stirring at rt for an additional hour. A 3 M solution of sodium hydroxide (100 mL) was cooled to 0 °C at the end of the reaction and transferred to a 250 mL separatory funnel. The reaction mixture was cooled to 0 °C and slowly transferred to the separatory funnel. The organic layer was carefully extracted, and the aqueous layer was washed with CH<sub>2</sub>Cl<sub>2</sub> (3 x 30 mL). The combined organic layers were dried with MgSO4, concentrated in vacuo, and purified via MPLC (40 g silica, 80 column volumes  $0\% \rightarrow 30\%$  EtOAC/Hex) to afford the desired product as a light orange gel (764.6 mg, 3.647 mmol, 71% yield; 112.3 mg, 0.574 mmol, 11% rsm). See Table 1 for product characterization.



1-(4-chlorophenyl)-5-ethylpyrrolidin-2-one [5] Following the general oxidation and a modified DASTpromoted methylation procedures, 1-(4-chlorophenyl)pyrrolidin-2-one 2 (59.3 mg, 0.302 mmol, 1.00 equiv.) in MeCN (0.7 mL) was oxidized with (S,S)MnCF<sub>3</sub>PDP (2.0 mg, 0.0015 mmol, 0.005 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34  $\mu$ L, 0.604 mmol, 2 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M) at -36 °C via single addition protocol . Following oxidation, the crude was subjected to DAST (40  $\mu$ L, 0.302 mmol, 1 equiv.) at -78°C and stirred at RT for 1 hour. After 1 hour, the solution was brought to -78°C, and triethylaluminum (1.0 M in hexanes, 910  $\mu$ L, 0.906 mmol, 3 equiv.) was added. The solution was stirred at -78°C for three hours before being quenched. Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 45 CV 0% to 20%, 10 CV 20% EtOAc/Hex) to produce the desired compound as a white powder.

**Run 1** (33.8 mg, 0.151 mmol, 50% yield; 12% rsm by <sup>1</sup>H NMR)

**Run 2** (33.1 mg, 0.148 mmol, 49% yield; 10% rsm by <sup>1</sup>H NMR)

**Run 3** (37.3 mg, 0.167 mmol, 55% yield; 13% rsm by <sup>1</sup>H NMR)

# Average overall yield: 51% (12% rsm) ± 2.6

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.36 (m, 4H), 4.16 (tdd, *J* = 8.2, 5.0, 3.0 Hz, 1H), 2.69 – 2.60 (m, 1H), 2.60 – 2.51 (m, 1H), 2.33 (m, 1H), 1.91 – 1.82 (m, 1H), 1.76 – 1.65 (m, 1H), 1.44 (m, 1H), 0.88 (t, *J* = 7.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.51, 136.42, 131.11, 129.23, 125.23, 60.77, 31.42, 26.07, 23.31, 8.78 <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>15</sub>ClNO [M+H]<sup>+</sup>: 224.0842, found 224.0839.



**1-(4-chlorophenyl)-6-methylpiperidin-2-one [6]** Following the general oxidation and DAST-promoted methylation, 1-(4-chlorophenyl)piperidin-2-one **S5** (63.3 mg, 0.302 mmol, 1.00 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (S,S)-MnCF<sub>3</sub>PDP (8.2 mg, 0.00604 mmol, 0.02 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (34  $\mu$ L, 0.604 mmol, 2 equiv.) in MeCN (3.75 mL), at -36 °C via the single addition protocol. Following oxidation, the crude was subjected to DAST (40  $\mu$ L, 0.303 mmol, 1.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL 40%  $\rightarrow$  50%  $\rightarrow$  400 mL 60% EtOAc/Hex) to afford the desired product as a pale yellow oil in an average of 58% yield.

Run 1 (41.1 mg, 0.184 mmol, 61% yield; 5% rsm by <sup>1</sup>H NMR) Run 2 (38.5 mg, 0.172 mmol, 57% yield; 5% rsm by <sup>1</sup>H NMR) Run 3 (37.2 mg, 0.166 mmol, 55% yield; 4% rsm by <sup>1</sup>H NMR) Average overall yield: 58% (5% rsm) ± 2.5 <u><sup>1</sup>H NMR</u>: (500 MHz, CDCl<sub>3</sub>) δ 7.36 (d, *J* = 8.6 Hz, 2H), 7.10 (d, *J* = 8.6 Hz, 2H), 3.89 (sxt, *J* = 6.3 Hz, 1H), 2.52 (t, *J* = 6.6 Hz, 2H), 2.14 – 2.06 (m, 1H), 2.03 – 1.93 (m, 1H), 1.89 – 1.79 (m, 1H), 1.72 (dddd, *J* = 13.3, 8.8, 6.2, 3.0 Hz, 1H), 1.06 (d, *J* = 6.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.70, 140.33, 133.05, 129.76, 129.65, 56.07, 33.07, 31.15, 21.22, 18.64

#### HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>15</sub>CINO [M+H]<sup>+</sup>: 224.0842, found 224.0845.



Oxidation of **6** using 10 mol% **1** and 5 equiv. H<sub>2</sub>O<sub>2</sub>: 40.5 mg, 0.181 mmol, 60% imide; 4.1 mg, 0.151 mmol, 5% hemiaminal acetate; 6.8 mg, 0.0302 mmol, 10% hemiaminal, 5.0 mg, 0.0242 mmol, 8% olefin. <sup>1</sup>H NMR (500 MHz, Chloroform-*d*)  $\delta$  7.42 (d, *J* = 8.2 Hz, 2H), 7.03 (d, *J* = 8.3 Hz, 2H), 2.82 (t, *J* = 6.5 Hz, 4H), 2.10 (p, *J* = 6.5 Hz, 2H).



**3-(4-bromophenyl)-4-methyloxazolidin-2-one [8]** According to a modified general oxidation and DAST-promoted methylation procedures, 3-(4-bromophenyl)oxazolidin-2-one **S6** (72.6 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.8 mL, 0.375 M) was placed in ice bath and oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34.6  $\mu$ L, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with DAST (39.6  $\mu$ L, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10% $\rightarrow$ 200 mL 20% $\rightarrow$ 400 mL 30% EtOAc/Hex) to afford the product as a white powder.

Run 1 (48.6 mg, 0.190 mmol, 63% yield)

Run 2 (49.6 mg, 0.194 mmol, 65% yield)

Run 3 (46.2 mg, 0.180 mmol, 60% yield)

Average overall yield: 63% (0% rsm)  $\pm 2.5$ 

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.50 (d, *J* = 8.9 Hz, 2H), 7.32 (d, *J* = 8.9 Hz, 2H), 4.57 (t, *J* = 8.3 Hz, 1H), 4.53-4.44 (m, 1H), 4.02 (dd, *J* = 8.3, 5.5 Hz, 1H), 1.33 (d, *J* = 6.1 Hz, 3H)

The spectral data match with those reported in the literature<sup>13</sup>.



**2-Methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine [9]** According to the general oxidation and BF<sub>3</sub>promoted methylation procedures, 1-((4-nitrophenyl)sulfonyl)pyrrolidine **S7** (76.9 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34.6  $\mu$ L, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (74.0  $\mu$ L, 0.60 mmol, 2.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10%→400 mL 20% EtOAc/Hex) to afford the product as a white solid.

**Run 1** (39.9 mg, 0.147 mmol, 49% yield; 4.6 mg, 0.018 mmol, 6% rsm; 20% 2,5-dimethylation by <sup>1</sup>H NMR, 1.4:1 dr)

**Run 2** (43.9 mg, 0.162 mmol, 54% yield, 6.0 mg, 0.023 mmol, 8% rsm; 10% 2,5-dimethylation by <sup>1</sup>H NMR, 1.3:1 dr)

**Run 3** (48.5 mg, 0.179 mmol, 60% yield, 9.6 mg, 0.037 mmol, 12% rsm; 14% 2,5-dimethylation by <sup>1</sup>H NMR, 1.3:1 dr)

Average overall yield: 54% (9% rsm) ± 5.5; 15% 2,5-dimethylation, 1.3:1 dr <sup>1</sup>H NMR: (500 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 8.8 Hz, 2H), 8.02 (d, *J* = 8.8 Hz, 2H), 3.76 (pd, *J* = 6.5, 3.8 Hz, 1H), 3.49 (ddd, *J* = 10.0, 7.0, 4.8 Hz, 1H), 3.17 (dt, *J* = 10.0, 7.2 Hz, 1H), 1.96-1.82 (m, 1H), 1.81-1.67 (m, 1H), 1.67-1.50 (m, 2H), 1.32 (d, *J* = 6.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.09, 144.14, 128.58, 124.40, 56.71, 49.19, 33.64, 24.06, 22.75 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>11</sub>H<sub>15</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 271.0753, found 271.0751.



(2R,5R)-2,5-dimethyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine [10] According to the general oxidation and BF<sub>3</sub>-promoted methylation procedures, (*R*)-2-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine S8 (81.1
mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34.6  $\mu$ L, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (74.0  $\mu$ L, 0.60 mmol, 2.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 5% $\rightarrow$ 600 mL 20% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds **13** and **42**. The <sup>1</sup>H NMR data matched those synthesized via an alternate route as reported by literature<sup>14</sup>.

**Run 1** (39.1 mg, 0.138 mmol, 46% yield, 1.4:1 dr; 11.0 mg, 0.041 mmol, 14% rsm)

**Run 2** (35.0 mg, 0.123 mmol, 41% yield, 2:1 dr; 13.5 mg, 0.050 mmol, 17% rsm)

Run 3 (33.5 mg, 0.118 mmol, 39% yield, 1.4:1 dr; 10.7 mg, 0.040 mmol, 13% rsm)

## Average overall yield: 42% (15% rsm) ± 3.6, 1.6:1 dr

Characterization of major diastereomer 10:

<sup>1</sup><u>H NMR:</u> (400 MHz, CDCl<sub>3</sub>)

δ 8.33 (d, J = 8.9 Hz, 2H), 8.04 (d, J = 8.9 Hz, 2H), 4.08 (app p, J = 6.5 Hz, 2H), 2.21-2.08 (m,

2H), 1.63-1.52 (m, 2H), 1.21 (d, *J* = 6.4 Hz, 6H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 149.76, 148.69, 128.17, 124.33, 56.99, 31.30, 21.57

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>17</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 285.0909, found 285.0911.  $[\alpha]_D^{24} = -21.6^{\circ}$  (c = 0.21, CH<sub>2</sub>Cl<sub>2</sub>)

Characterization of minor diastereomer S26:

# <sup>1</sup><u>H NMR:</u> (400 MHz, CDCl<sub>3</sub>)

δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.03 (d, *J* = 8.9 Hz, 2H), 3.80-3.58 (m, 2H), 1.70-1.52 (m, 4H), 1.37 (d, *J* = 6.3 Hz, 6H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

 $\delta \ 150.10, \ 144.34, \ 128.69, \ 124.37, \ 58.15, \ 32.30, \ 23.74$ 

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>12</sub>H<sub>17</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 285.0909, found 285.0916.

$$\underset{Me}{\overset{N}{\underset{H}{\overset{}}}} \underset{Me}{\overset{Ne}{\underset{H}{\overset{}}}} \underset{5\% \text{ Rh/Al_2O_3}{\overset{}}}{\overset{Me}{\underset{H}{\overset{}}} \underset{Me}{\overset{N}{\underset{H}{\overset{}}}} \underset{Me}{\overset{Ne}{\underset{H}{\overset{}}} \underset{H}{\overset{N}{\underset{H}{\overset{}}}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}}} \underset{Me}{\overset{Nel, Et_3N}{\overset{}} \underset{Me}{\overset{Ne}{\underset{Ns}{\overset{}}} \underset{(\pm)}{\overset{Ne}{\underset{Ns}{\overset{}}}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}}} \underset{Me}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{Nel, Et_3N}{\overset{}} \underset{(\pm)}{\overset{Nel, Et_3N}{\overset{Nel, Et_3N}{\overset{NE}$$

Synthesis of the reference compound: According to literature<sup>14</sup>, in a 25 mL recovery flask equipped with a magnetic stir bar were added 2,5-dimethylpyrrole (200 mg, 2.1 mmol, 1.0 equiv.), 5% rhodium on alumina (14.3 mg), and acetic acid (714  $\mu$ L). The flask was placed into a bomb, backfilled with hydrogen 3x, and pressurized with hydrogen to 40 psi. The reaction was stirred for 3 d. Upon completion, the reaction mixture as diluted with CH<sub>2</sub>Cl<sub>2</sub>, and rhodium was removed via filtration. The filtrate was basified with 3 M NaOH and extracted with CH<sub>2</sub>Cl<sub>2</sub> 3x. The combined organic layer was dried over K<sub>2</sub>CO<sub>3</sub>, filtered, and carefully condensed in vacuo. Crude NMR of the resulting free amine shows a 3:1 syn/anti diastereomeric ratio. The <sup>1</sup>H NMR data of the anti-isomer matched those reported in the literature<sup>15</sup>. The crude was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (20 mL), where NsCl (512 mg, 2.31 mmol, 1.1 equiv.) and Et<sub>3</sub>N (322  $\mu$ L, 2.31 mmol, 1.1 equiv.) were added and the reaction was stirred overnight. Upon completion, the reaction mixture was washed with sat. NaHCO<sub>3</sub> and the aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> 2x. The combined organic layer was dried over MgSO<sub>4</sub>, filtered, and condensed in vacuo. Purification by medium-pressure liquid chromatography (12 g silica, 100 column volumes 0%  $\rightarrow$  25% EtOAc/Hex) afforded nosyl 2,5-dimethylpyrrolidine as a mixture of diastereomers (193 mg, 0.680 mmol, 32% yield, 3:1 dr).

# <sup>1</sup><u>H NMR:</u> (400 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 8.8 Hz, 1.54H), 8.32 (d, *J* = 8.8 Hz, 0.46H), 8.08-7.96 (m, 2H), 4.07 (p, *J* = 6.4 Hz, 0.46H), 3.78-3.62 (m, 1.54H), 2.21-2.07 (m, 0.46H), 1.70-1.49 (m, 3.54H), 1.36 (d, *J* = 6.4 Hz, 2.31H), 1.20 (d, *J* = 6.4 Hz, 0.69H)

trans-2-(4-chlorophenyl)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine [(±)-11] According to the and general oxidation BF<sub>3</sub>-promoted methylation procedures, 2-(4-chlorophenyl)-1-((4nitrophenyl)sulfonyl)pyrrolidine S10 (73.4 mg, 0.20 mmol, 1.0 equiv.) in MeCN (0.4 mL, 0.5 M) was oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (5.4 mg, 0.006 mmol, 0.02 equiv.), AcOH (172 µL, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (57.7 μL, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M). Following oxidation, the crude was methylated with trimethylaluminum (2.0 M in hexanes, 300  $\mu$ L, 0.60 mmol, 3.0 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (49.3 µL, 0.40 mmol, 2.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 5%→10%→20% EtOAc/Hex) to afford the product as a white powder as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds 13 and 42.

**Run 1** (40.2 mg, 0.106 mmol, 53% yield, 1.3:1 dr; 8% rsm by <sup>1</sup>H NMR)

**Run 2** (45.8 mg, 0.120 mmol, 60% yield, 1.4:1 dr; 6% rsm by <sup>1</sup>H NMR)

**Run 3** (43.1 mg, 0.113 mmol, 57% yield, 1.7:1 dr; 6% rsm by <sup>1</sup>H NMR)

## Average overall yield: 57% (7% rsm) ± 3.5, 1.5:1 dr

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.31 (d, J = 8.8 Hz, 0.74H), 8.12 (d, J = 8.8 Hz, 1.26H), 7.90 (d, J = 8.8 Hz, 0.74H), 7.62 (d, J = 8.9 Hz, 1.26H), 7.27 (d, J = 9.1 Hz, 0.74H), 7.24 (d, J = 8.6 Hz, 0.74H), 7.08 (d, J = 8.4 Hz, 1.26H), 6.93 (d, J = 8.5 Hz, 1.26H), 4.97 (d, J = 8.4 Hz, 0.63H), 4.72 (t, J = 6.7 Hz, 0.37H), 4.34 (p, J = 6.5 Hz, 0.63H), 4.03 (sxt, J = 6.4 Hz, 0.37H), 2.53 (tdd, J = 12.9, 8.9, 7.1 Hz, 0.63H), 2.29 (tt, J = 12.8, 7.5 Hz, 0.63H), 2.03-1.96 (m, 0.37H), 1.93-1.85 (m, 0.37H), 1.85-1.74 (m, 1H), 1.70 (ddt, J = 12.7, 7.1, 1.3 Hz, 0.63H), 1.59 (dd, J = 11.8, 5.9 Hz, 0.37 H), 1.48 (d, J = 6.4 Hz, 1.11H), 1.43 (d, J = 6.4 Hz, 1.89H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.12, 149.52, 147.47, 144.37, 140.39, 140.27, 133.35, 133.43, 128.78, 128.77, 128.50, 128.34, 128.10, 127.91, 124.30, 123.82, 64.91, 63.27, 58.37, 58.34, 34.67, 33.16, 32.28, 31.85, 22.75, 22.12

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>18</sub>N<sub>2</sub>O<sub>4</sub>SCl [M+H]<sup>+</sup>: 381.0676, found 381.0683.



**methyl (2***S***,***SR***)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate [12]** According to the general oxidation and DAST-promoted methylation procedures, methyl ((4-nitrophenyl)sulfonyl)-*L*-prolinate **S11** (94.2 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257 µL, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (85.2 µL, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with DAST (39.6 µL, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10%→400 mL 20% EtOAc/Hex) to afford the product as a white solid or gel as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds **13** and **42** and by converting the product to methyl 1-((4-fluorophenyl)sulfonyl)-5-methylpyrrolidine-2-carboxylate and comparing the <sup>1</sup>H NMR spectra to those reported in the literature<sup>16</sup>. **Run 1** (71.9 mg, 0.219 mmol, 73% yield; 3:1 dr; 19% rsm by <sup>1</sup>H NMR)

**Run 3** (68.2 mg, 0.208 mmol, 69% yield, 3:1 dr; 13% rsm by <sup>1</sup>H NMR) Average overall yield: 68% (16% rsm) ± 5.6, 3:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 9.1 Hz, 0.5H), 8.33 (d, *J* = 8.8 Hz, 1.5H), 8.10 (d, *J* = 8.7 Hz, 0.5H), 8.04 (d, *J* = 9.0 Hz, 1.5H), 4.51 (dd, *J* = 8.6, 1.3 Hz, 0.75H), 4.39 (dd, *J* = 8.0, 5.5 Hz, 0.25H), 4.08 (pd, *J* = 6.3, 1.7 Hz, 0.75H), 3.94 (sxt, *J* = 6.4 Hz, 0.25H), 3.74 (s, 0.75H), 3.67 (s, 2.25 H), 2.37-2.17 (m, 1.5H), 2.10-2.00 (m, 0.5H), 1.97 (ddt, *J* = 12.6, 6.3, 1.4 Hz, 0.75H), 1.94-1.86 (m, 0.25H), 1.69-1.58 (m, 1H), 1.30 (d, *J* = 6.4 Hz, 0.75H), 1.26 (d, *J* = 6.5 Hz, 2.25H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 172.43, 172.39, 150.19, 149.99, 146.46, 145.17, 128.86, 128.79, 124.34, 124.10, 61.92, 61.68, 58.04, 56.63, 52.73, 52.53, 33.03, 32.14, 29.55, 28.69, 21.75, 21.60

# HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 329.0807, found 329.0800.



Synthesis of the reference compound: In a 25 mL recovery flask equipped with a magnetic stir bar were added methyl 5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate **12** (75.7 mg, 2.6:1 anti/syn, 0.23 mmol, 1.0 equiv.), cesium carbonate (300 mg, 0.92 mmol, 4.0 equiv.), MeCN (8.5 mL). The flask was backfilled with nitrogen 3x, and DMSO (171  $\mu$ L) and thiophenol (83  $\mu$ L, 0.81 mmol, 3.5 equiv.) were added. The reaction was stirred in 45 °C oil bath for 2 d. Upon completion, the reaction mixture as diluted with CH<sub>2</sub>Cl<sub>2</sub>, and washed with sat. NaHCO<sub>3</sub>. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> 3x. The combined organic layer was dried over K<sub>2</sub>CO<sub>3</sub>, filtered, and carefully condensed in vacuo at 0 °C. Purification by flash chromatography (50 mL silica, 200 mL 50% EtOAc/Hex $\rightarrow$ 10% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) followed by condensation in vacuo at 0 °C produced the free amine as a mixture with water and CH<sub>2</sub>Cl<sub>2</sub>. The water was removed using a separatory funnel and the aqueous layer extracted with CH<sub>2</sub>Cl<sub>2</sub> 1x. The combined organic layer was dried over K<sub>2</sub>CO<sub>3</sub>, filtered, and 4-fluorosulfonyl chloride (224 mg, 1.15 mmol, 5.0 equiv.) and triethylamine (160  $\mu$ L, 1.15 mmol, 5.0 equiv.) were added directed, and the reaction was stirred overnight. Upon completion, the reaction mixture was washed with sat. NaHCO<sub>3</sub> and

the aqueous layer was extracted with  $CH_2Cl_2$  2x. The combined organic layer was dried over MgSO<sub>4</sub>, filtered, and condensed in vacuo. Purification by medium-pressure liquid chromatography (12 g silica, 100 column volumes  $0\% \rightarrow 40\%$  EtOAc/Hex) afforded methyl 1-((4-fluorophenyl)sulfonyl)-5-methylpyrrolidine-2-carboxylate as a mixture of diastereomers (30.4 mg, 0.101 mmol, 44% yield, 2:1 anti/syn). The <sup>1</sup>H NMR data of the syn product matched those reported in the literature<sup>16</sup>.

<sup>1</sup><u>H NMR:</u> (400 MHz, CDCl<sub>3</sub>)

δ 7.96-7.86 (m, 2H), 7.23-7.12 (m, 2H), 4.49-4.43 (m, 0.67H), 4.30 (dd, J = 8.1, 5.5 Hz, 0.33H), 4.10-4.01 (m, 0.67H), 3.85 (sxt, J = 6.4 Hz, 0.33H), 3.74 (s, 1H), 3.66 (s, 2H), 2.36-2.18 (m, 1.34H), 2.08-1.90 (m, 1.33H), 1.90-1.78 (m, 0.33H), 1.69-1.52 (m, 1H), 1.31 (d, J = 6.4 Hz, 1H), 1.22 (d, J = 6.5 Hz, 2H)



**1-((25,5***R***)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)ethan-1-one [13]** According to the general oxidation procedure, (*S*)-1-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)ethan-1-one **S12** (59.7 mg, 0.20 mmol, 1.0 equiv.) in MeCN (0.4 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (1.4 mg, 0.0010 mmol, 0.005 equiv.), AcOH (172  $\mu$ L, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (56.8  $\mu$ L, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M). Following oxidation, the crude was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.0 mL, 0.2 M), backfilled with nitrogen 3x, and placed into a -78 °C dry ice/acetone bath. DAST (26.4  $\mu$ L, 32.2 mg, 0.20 mmol, 1.0 equiv.) was added, and the reaction was allowed to warm to room temperature while stirring for 1 h. The reaction was then placed back into -78 °C cold bath, where trimethylaluminum (2.0 M in hexanes, 300  $\mu$ L, 0.60 mmol, 3.0 equiv.) was then added dropwise. The reaction mixture was stirred at -78 °C for 3 h, and then directly quenched with 1 M NaOH. Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10%→400 mL 20%→200 mL 30% EtOAc/Hex) to afford the product as a white solid. The stereochemistry was determined based on <sup>1</sup>H NMR, COSY, NOESY 1D, and NOESY 2D NMR methods. **Run 1** (44.3 mg, 0.142 mmol, 71% yield; 3:1 dr; 3% rsm by <sup>1</sup>H NMR)

**Run 2** (46.0 mg, 0.147 mmol, 74% yield, 3:1 dr; 3% rsm by <sup>1</sup>H NMR)

Run 3 (45.8 mg, 0.147 mmol, 73% yield, 3:1 dr)

## Average overall yield: 73% (2% rsm) ± 1.5, 3:1 dr

Characterization of major diastereomer 13:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.00 (d, *J* = 8.8 Hz, 2H), 4.64 (dd, *J* = 9.4, 1.7 Hz, 1H), 4.02 (p, *J* = 6.6 Hz, 1H), 2.37-2.25 (m, 1H), 2.22 (s, 3H), 2.06 (tt, *J* = 12.5, 7.2 Hz, 1H), 1.85 (ddt, *J* = 13.2, 7.0, 1.8 Hz, 1H), 1.63-1.56 (m, 1H), 1.25 (d, *J* = 6.3 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 206.07, 150.02, 146.39, 128.94, 124.09, 67.95, 56.56, 31.96, 27.04, 26.81, 21.26 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>5</sub>S [M+H]<sup>+</sup>: 313.0858, found 313.0862.

 $[\alpha]_{D}^{24} = -35.5^{\circ} (c = 0.81, CH_2Cl_2)$ 



For COSY and NOESY see Supporting Information: Spectral Data



Characterization of minor diastereomer S27:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.39 (d, *J* = 8.8 Hz, 2H), 8.06 (d, *J* = 8.7 Hz, 2H), 4.09 (t, *J* = 7.4 Hz, 1H), 3.85 (td, *J* = 6.8, 4.6 Hz, 1H), 2.37 (s, 3H), 2.05-1.95 (m, 1H), 1.86 (dq, *J* = 13.0, 6.9 Hz, 1H), 1.77-1.67 (m, 1H), 1.61-1.52 (m, 1H), 1.37 (d, *J* = 6.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 207.09, 150.46, 143.49, 129.06, 124.53, 69.30, 58.34, 32.66, 27.98, 25.94, 22.53 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>5</sub>S [M+H]<sup>+</sup>: 313.0858, found 313.0869. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -69.6° (c = 0.57, CH<sub>2</sub>Cl<sub>2</sub>)



For COSY and NOESY see Supporting Information: Spectral Data



((2S,5R)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methyl acetate [14] According to the general oxidation and DAST-promoted methylation procedures, (S)-(1-((4nitrophenyl)sulfonyl)pyrrolidin-2-yl)methyl acetate S13 (98.5 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34.6 µL, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with DAST (39.6  $\mu$ L, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10%->400 mL 20% EtOAc/Hex) to afford the product as a light yellow solid as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds 13 and 42, and by reducing 12 with LiAlH<sub>4</sub> and acetylating the resulting alcohol to form 14 (3:1 dr anti/syn) as a reference. The  $^{1}$ H NMR data of the reduction/acetylation product matched those obtained via oxidative methylation.

Run 1 (69.2 mg, 0.202 mmol, 67% yield; 1.7:1 dr; 4.0 mg, 0.012 mmol, 4% rsm)

**Run 2** (70.7 mg, 0.207 mmol, 69% yield, 1.7:1 dr; 10.4 mg, 0.0316 mmol, 11% rsm)

**Run 3** (68.4 mg, 0.200 mmol, 67% yield, 1.7:1 dr; 13.1 mg, 0.0400 mmol, 13% rsm)

# Average overall yield: 68% (9% rsm) ± 1.2, 1.7:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 8.4 Hz, 0.76H), 8.33 (d, *J* = 8.7 Hz, 1.24H), 8.09-8.00 (m, 2H), 4.37-4.28 (m, 0.62H), 4.20 (dd, *J* = 11.1, 4.8 Hz, 0.38H), 4.16-4.09 (m, 1H), 4.10-3.98 (m, 1.24H), 3.90 (td, *J* = 7.1, 3.6 Hz, 0.38H), 3.70 (sxt, *J* = 6.3 Hz, 0.38H), 2.21-2.01 (m, 1.52H), 2.07 (s, 1.14H), 1.96 (s, 1.86H), 1.86 (dd, *J* = 12.2, 6.1 Hz, 0.62H), 1.78-1.68 (m, 0.62H), 1.57 (dq, *J* = 9.8, 5.1 Hz, 1.24H), 1.36 (d, *J* = 6.3 Hz, 1.14H), 1.20 (d, *J* = 6.4 Hz, 1.86H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.77, 170.49, 150.29, 149.22, 147.69, 143.76, 128.84, 128.28, 124.49, 124.40, 66.26, 64.83, 59.85, 58.43, 58.30, 57.71, 32.32, 31.45, 27.46, 27.04, 23.00, 21.11, 20.99, 20.87

# HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>14</sub>H<sub>19</sub>N<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 343.0964, found 343.0960.



(2S)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonitrile [15] To a 40 mL vial equipped with a stir bar were added (S)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonitrile S14 (84.4 mg, 0.30 mmol, 1.0 equiv.), MeCN (0.6 mL, 0.5 M), and AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.). The vial was then placed into ice bath while stirring. A 1 mL syringe was charged with (S,S)-Mn(CF<sub>3</sub>PDP) (2.0 mg,

0.0015 mmol, 0.005 equiv.) in MeCN (0.375 mL, 0.004 M to catalyst). Likewise, a 10 mL syringe was charged with  $H_2O_2$  (85.2 µL, 1.50 mmol, 5.0 equiv, 50 wt.% in  $H_2O$ ) in MeCN (3.75 mL, 0.4 M). Both syringes were fitted with 25G needles and solutions were added simutaneously using the same syringe pump over 1 h at 0 °C. The reaction mixture was then worked up according to the general oxidation procedure. Following work up, the crude was methylated with DAST (39.6 µL, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 10% $\rightarrow$ 600 mL 20% EtOAc/Hex) to afford the product as a white gel as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds **13** and **42**.

**Run 1** (42.8 mg, 0.145 mmol, 48% yield; 1.5:1 dr; 26% rsm by <sup>1</sup>H NMR)

**Run 2** (38.2 mg, 0.129 mmol, 43% yield, 1.5:1 dr; 28% rsm by <sup>1</sup>H NMR)

**Run 3** (38.3 mg, 0.130 mmol, 43% yield, 1.5:1 dr; 32% rsm by <sup>1</sup>H NMR)

# Average overall yield: 45% (29% rsm) ± 2.9, 1.5:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.40 (d, *J* = 8.8 Hz, 2H), 8.15 (d, *J* = 8.6 Hz, 1.2H), 8.11 (d, *J* = 8.6 Hz, 0.8H), 4.76 (d, *J* = 7.5 Hz, 0.6H), 4.73 (dd, *J* = 8.2, 3.8 Hz, 0.4H), 4.04 (sxt, *J* = 6.5 Hz, 0.4H), 3.86 (p, *J* = 6.7 Hz, 0.6H), 2.44-2.31 (m, 0.6H), 2.30-2.09 (m, 2.4H), 1.91-1.77 (m, 1H), 1.40 (d, *J* = 6.4 Hz, 1.8H), 1.31 (d, *J* = 6.3 Hz, 1.2H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.56, 150.47, 145.13, 143.62, 129.31, 128.64, 124.73, 124.44, 118.45, 116.93, 58.21, 56.20, 50.12, 49.62, 33.43, 32.72, 30.88, 29.41, 22.44, 21.60

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>11</sub>H<sub>13</sub>N<sub>2</sub>O<sub>4</sub>S [M-CN]<sup>+</sup>: 269.0596, found 269.0589.



trans-2-methyl-1-((4-nitrophenyl)sulfonyl)-4-phenylpyrrolidine [(±)-16] According to a modified general oxidation procedure and the BF<sub>3</sub>-promoted methylation procedure, 1-((4-nitrophenyl)sulfonyl)-3-phenylpyrrolidine S15 (99.7 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34.6  $\mu$ L, 0.60 mmol, 2.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M) at 0 °C in ice bath. Following oxidation, the crude was methylated with trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (74.0  $\mu$ L, 0.60 mmol, 2.0 equiv.). Following workup, the crude material

was purified by medium-pressure liquid chromatography (24 g silica, 70 column volumes  $0\% \rightarrow 20\%$  EtOAc/Hex) to afford the product as a light yellow solid as a mixture of diastereomers. The stereochemistry was determined by <sup>1</sup>H NMR, NOESY 2D, and COSY methods.

Run 1 (36.5 mg, 0.105 mmol, 35% yield, 6:1 dr; 31.6 mg, 0.0951 mmol, 32% rsm)

**Run 2** (38.5 mg, 0.123 mmol, 37% yield, 6:1 dr; 26.4 mg, 0.0794 mmol, 26% rsm)

**Run 3** (35.3 mg, 0.102 mmol, 34% yield, 7:1 dr; 21.1 mg, 0.0635 mmol, 21% rsm)

## Average overall yield: 35% (26% rsm) ± 1.5, 6:1 dr

Characterization of major diastereomer 16:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.35 (d, *J* = 8.8 Hz, 2H), 8.01 (d, *J* = 8.8 Hz, 2H), 7.28-7.18 (m, 3H), 7.06-7.03 (m, 2H), 3.99 (qd, *J* = 6.4, 4.3 Hz, 1H), 3.91 (dd, *J* = 9.4, 7.2 Hz, 1H), 3.56 (p, *J* = 8.8 Hz, 1H), 3.06 (t, *J* = 9.7 Hz, 1H), 1.97-1.90 (m, 2H), 1.44 (d, *J* = 6.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.19, 143.60, 139.42, 128.87, 128.65, 127.36, 126.96, 124.44, 56.64, 55.48, 41.67, 39.81, 23.44

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>19</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 347.1066, found 347.1059.



For COSY and NOESY see Supporting Information: Spectral Data



methyl (2*S*,6*S*)-1-((4-(methoxycarbonyl)phenyl)sulfonyl)-6-methylpiperidine-2-carboxylate [17] Following the general oxidation and BF<sub>3</sub>-promoted methylation, (*S*)-1-((4-(methoxycarbonyl)phenyl)sulfonyl)piperidine-2-carboxylate **S16** (103.1 mg, 0.302 mmol, 1.00 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-MnCF<sub>3</sub>PDP (4.1 mg, 0.003 mmol, 0.01 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.51 mmol, 5 equiv.) in MeCN (3.75 mL), at -36 °C via the single addition protocol. Following oxidation, the crude was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75  $\mu$ L, .604 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by Medium Pressure Liquid Chromatography (40 g silica, liquid sample, gradient elution of 40 CV from 0% to 15% EtOAc/Hex) to afford the desired product as a pale white solid in an average of 47% yield.

**Run 1** (48.3 mg, 0.136 mmol, 45% yield; 0% rsm and >20:1 dr by <sup>1</sup>H NMR. 20% C=C observed by crude NMR)

**Run 2** (51.5 mg, 0.145 mmol, 48% yield; 0% rsm and >20:1 dr by <sup>1</sup>H NMR. 23% C=C observed by crude NMR)

**Run 3** (50.4 mg, 0.142 mmol, 47% yield; 0% rsm and >20:1 dr by <sup>1</sup>H NMR. 24% C=C observed by crude NMR)

Average overall yield: 47% (0% rsm) ± 1.2, >20:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.16 (d, *J* = 8.4 Hz, 2H), 7.94 (d, *J* = 8.1 Hz, 2H), 4.82 (d, *J* = 5.0 Hz, 1H), 4.12 (tq, *J* = 6.9, 3.8 Hz, 1H), 3.95 (s, 3H), 3.67 (s, 3H), 2.29 (d, *J* = 11.0 Hz, 1H), 1.71 – 1.62 (m, 1H), 1.53 – 1.37 (m, 5H), 1.05 (d, *J* = 7.1 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 172.54, 165.84, 145.13, 133.68, 130.21, 127.38, 52.74, 52.68, 52.39, 49.07, 29.61, 25.90,

18.30, 15.14

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>21</sub>NNaO<sub>6</sub>S [M+Na]<sup>+</sup>: 378.0987, found 358.0993. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -27.8 (c = 1.00, EtOH)



For NOESY and decoupling see Supporting Information: Spectral Data. Both  $H_A$  and  $H_B$  were shown to be equatorial and *cis* to each other because of their coupling constants and NOESY correlations.



The enamine was observed in an average of 22% yield (see above). When submitting the substrate to the same conditions but using DAST (1 equiv.) as the activator, 60% enamine was isolated with trace (2%) product.

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.19 (d, *J* = 8.2 Hz, 2H), 7.88 (d, *J* = 8.1 Hz, 2H), 6.70 (d, *J* = 8.4 Hz, 1H), 5.09-5.03 (m, 1H), 4.76-4.73 (m, 1H), 3.97 (s, 3H), 3.66 (s, 3H), 2.23 (d, *J* = 13.7 Hz, 1H), 1.97-1.84 (m, 2H), 1.47 (dt, *J* = 17.0, 7.9 Hz, 1H).

Me Ns OAc

((2*S*,6*S*)-6-methyl-1-((4-nitrophenyl)sulfonyl)piperidin-2-yl)methyl acetate [18] Following the general oxidation and DAST-promoted methylation, (*S*)-(1-((4-nitrophenyl)sulfonyl)piperidin-2-yl)methyl acetate S17 (103.4 mg, 0.302 mmol, 1.00 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.51 mmol, 5 equiv.) in MeCN (3.75 mL), at -36 °C via the single addition protocol. Following oxidation, the crude was subjected to DAST (40  $\mu$ L, 0.303 mmol, 1.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 36 CV 0% to 12%, 10 CV from 12% to 15% EtOAc/Hex) to afford the desired product as a white powder in an average of 64% yield.

**Run 1:** 65.6 mg, 0.184 mmol, 61% yield; 0% rsm and 14% C=C by <sup>1</sup>H NMR and >20:1 dr by <sup>1</sup>H NMR. **Run 2:** 70.0 mg, 0.196 mmol, 65% yield; 0% rsm and 9% C=C by <sup>1</sup>H NMR and >20:1 dr by <sup>1</sup>H NMR. **Run 3:** 69.6 mg, 0.195 mmol, 65% yield; 0% rsm and 12% C=C by <sup>1</sup>H NMR and >20:1 dr by <sup>1</sup>H NMR. **Average overall yield: 64% yield (0% rsm) \pm 1.9.** 

<sup>1</sup>H NMR: (500 MHz, Chloroform-*d*)

δ 8.34 (d, *J* = 8.8 Hz, 2H), 8.01 (d, *J* = 8.8 Hz, 2H), 4.35 (dd, *J* = 10.6, 8.3 Hz, 1H), 4.27 (q, *J* = 6.9 Hz, 1H), 4.12 (p, *J* = 5.6 Hz, 1H), 4.07 (dd, *J* = 10.6, 6.6 Hz, 1H), 2.09 (s, 3H), 1.73 – 1.57 (m, 2H), 1.52 – 1.43 (m, 1H), 1.39 (dt, *J* = 14.2, 3.8 Hz, 1H), 1.32 (d, *J* = 7.1 Hz, 3H), 1.30 – 1.22 (m, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 171.02, 150.13, 147.52, 128.15, 124.73, 64.78, 51.04, 48.77, 29.57, 25.08, 22.20, 21.24, 13.79. <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>15</sub>H<sub>20</sub>N<sub>2</sub>NaO<sub>6</sub>S [M+Na]<sup>+</sup>: 379.0940, found 379.0932 [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -7.29 (c = 1.00, EtOH)



For NOESY see Supporting Information: Spectral Data



6-fluoro-3-(trans-2-methyl-1-((4-nitrophenyl)sulfonyl)piperidin-4-yl)benzo[d]isoxazole [(±)-19] According to modified general oxidation and DAST-promoted methylation procedures, in a 40-mL vial were added 6-fluoro-3-(1-((4-nitrophenyl)sulfonyl)piperidin-4-yl)benzo[d]isoxazole **S18** (121.6 mg, 0.30 mmol, 1.0 equiv.), 1:1.7 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (2.7 mL, 0.11 M), and AcOH (257 μL, 4.50 mmol, 15.0 equiv.). H<sub>2</sub>O<sub>2</sub> (85.2 µL, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (3.75 mL) and (S.S)-Mn(CF<sub>3</sub>PDP) (40.7 mg, 0.03 mmol, 0.10 equiv.) in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (0.37 mL) were transferred to 10 mL and 1 mL synringes and added concurrently via a syringe pump into the vial in 1 h at room temperature. Following oxidation and workup, the oxidation products were isolated from the starting material through flash chromatography (50 mL silica, 200 mL 2% MeOH/CH<sub>2</sub>Cl<sub>2</sub>), and methylated with DAST (39.6 µL, 48.3 mg, 0.30 mmol, 1.0 equiv.) (florination at -78 °C for 10 min, then room temperature for 50 min) and trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, 300 mL 20% EtOAc/Hex) to afford the product as a white solid. The starting material was resubjected to the reaction conditions 1x. The stereochemistry was determined based on <sup>1</sup>H NMR, COSY, and NOESY 2D NMR methods.

**Run 1** (1<sup>st</sup> cycle: 37.7 mg, 0.0898 mmol, 30% yield, >20:1 dr; 42.2 mg, 0.104 mmol, 35% rsm. 2<sup>nd</sup> cycle: 10.0 mg, 0.0238 mmol, 23% yield, >20:1 dr; 17.7 mg, 0.0438 mmol, 42% rsm. Overall: 47.7 mg, 0.114 mmol, 38% yield, >20:1 dr; 17.7 mg, 0.0438 mmol, 15% rsm)

**Run 2** (1<sup>st</sup> cycle: 34.8 mg, 0.0830 mmol, 28% yield, >20:1 dr; 33.0 mg, 0.0814 mmol, 27% rsm. 2<sup>nd</sup> cycle: 11.9 mg, 0.0283 mmol, 35% yield, >20:1 dr; 11.4 mg, 0.0281 mmol, 35% rsm. Overall: 46.7 mg, 0.111 mmol, 37% yield, >20:1 dr; 11.4 mg, 0.0281 mmol, 9% rsm)

**Run 3** (1<sup>st</sup> cycle: 37.7 mg, 0.0898 mmol, 30% yield, >20:1 dr; 35.6 mg, 0.0878 mmol. 29% rsm. 2<sup>nd</sup> cycle: 6.3 mg, 0.015 mmol, 17% yield, >20:1 dr; 17.2 mg, 0.0424 mmol, 48% rsm. Overall: 44.0 mg, 0.105 mmol, 35% yield, >20:1 dr; 17.2 mg, 0.0424 mmol, 14% rsm)

Average overall yield: 37% (13% rsm) ± 1.5, >20:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.38 (d, *J* = 8.9 Hz, 2H), 8.05 (d, *J* = 8.8 Hz, 2H), 7.52 (dd, *J* = 8.7, 5.0 Hz, 1H), 7.26-7.22 (m, 1H), 7.06 (td, *J* = 8.8, 2.1 Hz, 1H), 4.53 (p, *J* = 6.3 Hz, 1H), 4.05-3.96 (m, 1H), 3.45 (tt, *J* = 12.4, 3.5 Hz, 1H), 3.27 (td, *J* = 13.4, 2.7 Hz, 1H), 2.16-2.05 (m, 2H), 1.99-1.91 (m, 1H), 1.88 (qd, *J* = 13.0, 4.6 Hz, 1H), 1.27 (d, *J* = 6.9 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 164.27 (d, *J* = 251.3 Hz), 164.19 (d, *J* = 14.0 Hz), 160.06, 150.11, 147.01, 128.28, 124.69, 122.13 (d, *J* = 11.1 Hz), 116.85, 112.90 (d, *J* = 25.3 Hz), 97.88 (d, *J* = 26.9 Hz), 48.81, 40.13, 35.32, 30.25, 28.85

<sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

 $\delta$  -108.67 (td, J = 8.6, 5.1 Hz)

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>19</sub>N<sub>3</sub>O<sub>5</sub>SF [M+H]<sup>+</sup>: 420.1029, found 420.1041.



For COSY and NOESY see Supporting Information: Spectral Data



trans-4-(4-bromophenyl)-2-methyl-1-(phenylsulfonyl)piperidine [( $\pm$ )-20] Following the general oxidation and BF<sub>3</sub>-promoted methylation procedures, 4-(4-bromophenyl)-1-(phenylsulfonyl)piperidine **S19** (114.9 mg, 0.302 mmol, 1.00 equiv.) in 4:1 MeCN/DCM (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (8.2 mg, 0.006 mmol, 0.02 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.5 mmol, 5 equiv., 50 wt.% in H<sub>2</sub>O) in 4:1 MeCN/DCM (3.75 mL), at 0 °C via the single addition protocol. Following oxidation, the crude was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75  $\mu$ L, 0.60 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 20 CV 0% to 5%, 15 CV 5%, 10 CV 5% to 10% EtOAc/Hex) to produce the desired compound as a white powder.

**Run 1:** 42.9 mg, 0.109 mmol, 36% yield; 39% rsm and > 20:1 dr by <sup>1</sup>H NMR

**Run 2:** 44.2 mg, 0.112 mmol, 37% yield; 40% rsm and > 20:1 dr by <sup>1</sup>H NMR

**Run 3:** 45.2 mg, 0.114 mmol, 38% yield; 33% rsm and > 20:1 dr by <sup>1</sup>H NMR

## Average overall yield: 39% yield $(37\% \text{ rsm}) \pm 0.8$ , > 20:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.86 (d, *J* = 7.2 Hz, 2H), 7.58 (t, *J* = 7.4 Hz, 1H), 7.52 (t, *J* = 7.5 Hz, 2H), 7.39 (d, *J* = 8.5 Hz, 2H), 6.95 (d, *J* = 8.4 Hz, 2H), 4.43 (p, *J* = 7.1, 1H), 3.91 (ddd, *J* = 13.8, 4.8, 2.2 Hz, 1H), 3.13 (td, *J* = 13.2, 2.7 Hz, 1H), 2.81 (tt, *J* = 12.7, 3.7 Hz, 1H), 1.78 – 1.66 (m, 2H), 1.63-1.60 (m, 1H), 1.51 (qd, *J* = 12.9, 4.7 Hz, 1H), 1.16 (d, *J* = 7.0 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-d)

δ 144.17, 141.34, 132.49, 131.75, 129.24, 128.60, 127.12, 120.31, 48.78, 40.29, 37.94, 35.69, 32.68, 15.91

## HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>21</sub>BrNO<sub>2</sub>S [M+H]<sup>+</sup>: 394.0476, found 394.0470.



For COSY and NOESY see Supporting Information: Spectral Data



**2-methyl-1-((4-nitrophenyl)sulfonyl)azepane [21]** Following the general oxidation and BF<sub>3</sub>-promoted methylation procedures, 1-((4-nitrophenyl)sulfonyl)azepane **S20** (85.9 mg, 0.302 mmol, 1 equiv.) in MeCN/DCM (1.7:1 mL) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (4.1 mg, 0.003 mmol, 0.01 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.5 mmol, 5 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN/DCM (2.6:0.9 mL), at -36 °C via the single addition protocol.. Following oxidation, the crude was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75  $\mu$ L, .60 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL 0%  $\rightarrow$  1%  $\rightarrow$  2%  $\rightarrow$  3%  $\rightarrow$  400 mL 4% ethyl acetate in hexanes) to afford the desired product as a pale white solid. **Run 1**: 36.9 mg, 0.124 mmol, 41% yield: 10% rsm by <sup>1</sup>H NMR

**Run 2**: 34.2 mg, 0.115 mmol, 38% yield; 5% rsm by <sup>1</sup>H NMR

**Run 3**: 36.8 mg, 0.123 mmol, 41% yield; 5% rsm by <sup>1</sup>H NMR

#### Average overall yield: 40% yield (7% rsm) $\pm$ 1.4

The hemiaminal during C–H oxidation was likely opened and subsequently underwent overoxidation to the carboxylic acid, resulting in lower mass balance<sup>1</sup>.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.34 (d, 2H, *J* = 7.2 Hz), 8.03 (d, 2H, *J* = 7.0 Hz), 4.09-4.00 (m, 1H), 3.76 (dt, 1H, *J* = 15.2, 3.7 Hz), 2.96 (ddd, 1H, *J* = 15.2, 11.7, 2.1 Hz), 2.06 (m, 1H), 1.76 (m, 1H), 1.72-1.58 (m, 2H), 1.22 (m, 4H), 0.98 (d, 3H, *J* = 5.2 Hz)

## <sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 149.80, 148.05, 128.32, 124.41, 53.67, 43.00, 37.19, 29.80, 29.54, 24.54, 20.16

#### HRMS: (EI HR MS EI+)

m/z calculated for C<sub>13</sub>H<sub>18</sub>N<sub>2</sub>O<sub>4</sub>S [M]: 298.0987, found 298.0988.



**2-methyl-3-((4-nitrophenyl)sulfonyl)-3-azabicyclo[3.1.1]heptane [22]** Following the general oxidation and BF<sub>3</sub>-promoted methylation procedures, 3-((4-nitrophenyl)sulfonyl)-3-azabicyclo[3.1.1]heptane **S21** (85.3 mg, 0.302 mmol, 1 equiv.) in MeCN/DCM (1:0.25 mL) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), acetic acid (259 µL, 4.53 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34 µL, 0.60 mmol, 2 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN/DCM (2.8:0.7 mL), at 0 °C via the single addition protocol. Following oxidation, the crude was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75 µL, .60 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450 µL, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (70 mL silica, loaded with DCM, gradient elution 200 mL 0%  $\rightarrow$  1%  $\rightarrow$  2%  $\rightarrow$  3%  $\rightarrow$  4%  $\rightarrow$  5%  $\rightarrow$  6% ethyl acetate in hexanes) to afford the desired product as a pale white solid. **Run 1**: 35.0 mg, 0.118 mmol, 39% yield; 6% rsm by <sup>1</sup>H NMR; 2% dimethylated was isolated. **Run 2**: 36.7 mg, 0.124 mmol, 41% yield; 10% rsm by <sup>1</sup>H NMR; 1% dimethylated was isolated. **Run 3**: 34.7 mg, 0.117 mmol, 39% yield; 6% rsm by <sup>1</sup>H NMR; 3% dimethylated was isolated. **Average overall yield: 40% yield (7% rsm) ± 0.9** 

# The hemiaminal during C—H oxidation was likely opened and subsequently underwent overoxidation to the carboxylic acid, resulting in lower mass balance<sup>1</sup>.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.37 (d, *J* = 8.8 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 4.02 (qd, *J* = 6.3, 3.6 Hz, 1H), 3.57 (t, *J* = 11.0 Hz, 1H), 3.53 (dd, *J* = 26.6, 10.9 Hz, 1H), 2.36 (qdd, *J* = 5.8, 3.6, 1.6 Hz, 1H), 2.21 (qd, *J* =

6.0, 3.6 Hz, 1H), 2.02 – 1.95 (m, 1H), 1.92 (dt, *J* = 9.6, 5.9 Hz, 1H), 1.50 (dd, *J* = 10.0, 8.1 Hz, 1H), 1.40 (d, *J* = 6.3 Hz, 3H), 0.62 (dd, *J* = 9.7, 8.1 Hz, 1H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 150.07, 145.04, 128.65, 124.49, 57.44, 51.30, 38.77, 32.96, 30.42, 28.55, 20.78

# <u>HRMS:</u> (ESI TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>17</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 297.0909, found 297.0912.



*rel-*(2*S*,4*aR*,8*aS*)-2-methyl-1-((4-nitrophenyl)sulfonyl)decahydroquinoline [(±)-23] Following the general oxidation and BF<sub>3</sub>-promoted procedures, 1-((4-nitrophenyl)sulfonyl)-trans-decahydroquinoline **S22** (97.9 mg, 0.302 mmol, 1.00 equiv.) in MeCN/DCM (1.3 mL/0.3 mL) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), acetic acid (259 µL, 4.53 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (34 µL, 0.604 mmol, 2 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN/DCM (2.8 mL/0.7 mL), at -36 °C via the single addition protocol. Following oxidation, the crude was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75 µL, .60 mmol, 2.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450 µL, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, DCM loaded, gradient elution 200 mL 0%  $\rightarrow$  1%  $\rightarrow$  2%  $\rightarrow$  3%  $\rightarrow$  4%  $\rightarrow$  400 mL 5%  $\rightarrow$  200 mL 20% EtOAc/Hex) to afford the desired product as a white solid.

**Run 1:** 40.9 mg, 0.121 mmol, 40% yield; 12 % rsm and 5:1 dr by <sup>1</sup>H NMR.

**Run 2:** 41.0 mg, 0.121 mmol, 40% yield; 10% rsm and 5:1 dr by <sup>1</sup>H NMR.

**Run 3:** 38.6 mg, 0.114 mmol, 38% yield; 20% rsm and 5:1 dr by <sup>1</sup>H NMR.

# Average overall yield: 39% yield (14% rsm) ± 0.9, 5:1 dr

The product has poor solubility, which resulted in lower yields during isolation. A higher yield was obtained when the product was isolated as a mixture with the starting material. Following workup, the crude material was purified by flash chromatography (50 mL silica, DCM loaded, gradient elution 200 mL 10%  $\rightarrow$  20% EtOAc/Hex) to give a mixture of the desired product and the starting material.

**Run 1:** 46.0 mg, 0.136 mmol, 45% yield; 14 % rsm; 5:1 dr by <sup>1</sup>H NMR.

**Run 2:** 45.8 mg, 0.135 mmol, 45% yield; 13% rsm; 5:1 dr by <sup>1</sup>H NMR.

**Run 3:** 48.0 mg, 0.142 mmol, 47% yield; 19% rsm; 5:1 dr by <sup>1</sup>H NMR.

Average overall yield: 46% yield (15% rsm) ± 0.9, 5:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.31 (d, *J* = 8.9 Hz, 2H), 7.99 (d, *J* = 8.9 Hz, 2H), 4.71 (qdd, *J* = 7.0, 5.1, 2.2 Hz, 1H), 3.09 (ddd, *J* = 11.7, 10.0, 3.5 Hz, 1H), 2.02 – 1.94 (m, 1H), 1.90 (tt, *J* = 13.4, 4.8 Hz, 1H), 1.75 – 1.55 (m, 5H), 1.48 – 1.38 (m, 2H), 1.36 (d, *J* = 7.0 Hz, 3H), 1.34 – 1.21 (m, 1H), 1.22 – 1.08 (m, 2H), 1.02 (dddd, *J* = 13.0, 11.1, 7.9, 3.6 Hz, 1H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 150.57, 149.67, 128.09, 124.29, 59.33, 51.66, 41.61, 33.43, 30.92, 30.88, 27.00, 26.43, 25.38, 17.17

## HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>23</sub>N<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 339.1379, found 339.1387.



For NOESY see Supporting Information: Spectral Data



**6-bromo-1-methyl-2-((4-nitrophenyl)sulfonyl)-1,2,3,4-tetrahydroisoquinoline** [24] Following the general oxidation and BF<sub>3</sub>-promoted methylation protocols, 6-bromo-2-((4-nitrophenyl)sulfonyl)-1,2,3,4-tetrahydroisoquinoline **S23** (120 mg, 0.302 mmol, 1 equiv.) in MeCN/DCM (1.7 mL:1 mL) was oxidized with (*S,S*)-Mn(CF<sub>3</sub>PDP) (4.1 mg, 0.0030 mmol, 0.01 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.5 mmol, 5 equiv.) in MeCN/DCM (2.6 mL:0.9 mL), at 0 °C via the single addition protocol. Following oxidation, the crude mixture was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75  $\mu$ L, 0.604 mmol, 2 equiv.) and AlMe<sub>3</sub> (450  $\mu$ L, 0.90 mmol, 3 equiv.). Following workup, the resulting oil was purified using liquid chromatography (50 mL silica, loaded with DCM, 200 mL 0%  $\rightarrow$  2%  $\rightarrow$  4%  $\rightarrow$  600 mL 5% EtOAc/Hex) to afford the desired product as a transparent oil.

**Run 1:** 54.5 mg, 0.133 mmol, 44% yield; 5% rsm by <sup>1</sup>H NMR

**Run 2:** 56.0 mg, 0.136 mmol, 45% yield; 10% rsm by <sup>1</sup>H NMR

**Run 3:** 56.9 mg, 0.138 mmol, 46% yield; 5% rsm by <sup>1</sup>H NMR

# Average overall yield: 45% yield (7% rsm) ± 0.8

The product has poor solubility which resulted in lower yields during isolation. A higher yield was obtained when the product was isolated as a mixture with the starting material. Following workup, the

crude material was purified by flash chromatography (50 mL silica, DCM loaded, gradient elution 100 mL  $0\% \rightarrow 300$  mL 15% EtOAc/Hex) to give a mixture of the desired product and the starting material.

**Run 1:** 62.1 mg, 0.151 mmol, 50% yield; 7 % rsm by <sup>1</sup>H NMR

**Run 2:** 62.3 mg, 0.151 mmol, 50% yield; 6 % rsm by <sup>1</sup>H NMR

**Run 3:** 65.8 mg, 0.160 mmol, 53% yield; 6 % rsm by <sup>1</sup>H NMR

Average overall yield: 51% yield  $(6\% rsm) \pm 1.4$ .

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.27 (d, *J* = 8.8 Hz, 2H), 7.96 (d, *J* = 8.5 Hz, 2H), 7.30 (dd, *J* = 8.3, 2.0 Hz, 1H), 7.16 (d, *J* = 2.0 Hz, 1H), 6.94 (d, *J* = 8.3 Hz, 1H), 5.12 (q, *J* = 6.8 Hz, 1H), 4.01 – 3.88 (m, 1H), 3.45 (ddd, *J* = 13.8, 10.5, 5.3 Hz, 1H), 2.76 – 2.61 (m, 2H), 1.47 (d, *J* = 6.8 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 150.04, 146.88, 136.14, 134.56, 132.06, 129.98, 128.41, 128.11, 124.52, 120.82, 52.26, 38.55, 27.75, 23.54

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>16</sub>BrN<sub>2</sub>O<sub>4</sub>S [M+H]<sup>+</sup>: 411.0014, found 411.0016.



methyl (1*R*,3*S*)-2-((4-bromophenyl)sulfonyl)-1-methyl-1,2,3,4-tetrahydroisoquinoline-3-carboxylate [25] Following the general oxidation and BF<sub>3</sub>-promoted methylation protocols, methyl (*S*)-2-((4-bromophenyl)sulfonyl)-1,2,3,4-tetrahydroisoquinoline-3-carboxylate **S24** (123.9 mg, 0.302 mmol, 1 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (8.1 mg, 0.0060 mmol, 0.02 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.5 mmol, 5 equiv.) in MeCN (3.75 mL), at -36 °C via the single addition protocol. Following oxidation, the crude mixture was methylated with BF<sub>3</sub>•OEt<sub>2</sub> (75  $\mu$ L, 0.604 mmol, 2 equiv.) and AlMe<sub>3</sub> (450  $\mu$ L, 0.90 mmol, 3 equiv.). Following workup, the resulting oil was purified by MPLC (40 g silica, wet loaded with DCM, gradient elution 40 CV 0% to 20% EtOAc/Hex) to afford the desired product as a white solid.

**Run 1:** 64.7 mg, 0.152 mmol, 50% yield; 10% rsm and 2:1 dr by <sup>1</sup>H NMR.

**Run 2:** 56.0 mg, 0.151 mmol, 50% yield; 10% rsm and 2:1 dr by <sup>1</sup>H NMR.

**Run 3:** 61.5 mg, 0.145 mmol, 48% yield; 11% rsm and 2:1 dr by <sup>1</sup>H NMR.

Average overall yield: 50% yield  $(10\% \text{ rsm}) \pm 0.5$ , 2:1 dr

Characterization of major diastereomer:

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.79 (d, *J* = 8.7 Hz, 2H), 7.64 (d, *J* = 8.7 Hz, 2H), 7.21 (t, *J* = 6.0 Hz, 1H), 7.16 (td, *J* = 7.5, 1.4 Hz, 1H), 7.10 – 7.03 (m, 2H), 5.05 (q, *J* = 6.8 Hz, 1H), 4.89 (dd, *J* = 5.4, 3.9 Hz, 1H), 3.44 (s, 3H), 3.33 (dd, *J* = 15.6, 5.4 Hz, 1H), 3.19 (dd, *J* = 15.6, 3.9 Hz, 1H), 1.50 (d, *J* = 6.5 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 171.41, 140.15, 139.28, 132.31, 130.41, 129.22, 128.48, 127.80, 127.74, 127.38, 126.15, 56.49, 54.71, 52.43, 32.73, 26.13

## HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>19</sub>BrNO<sub>4</sub>S [M-H]<sup>+</sup>: 424.0218, found. 424.0204.

 $[\alpha]_D^{24} = -5.888 \text{ (c} = 1.00, \text{EtOH)}$ 



For NOESY see Supporting Information: Spectral Data



**6,8-dibromo-1-methylisochromane** [26] Following the general oxidation and DAST-promoted methylation, 6,8-dibromoisochromane S25 (88.2 mg, 0.302 mmol, 1.00 equiv.) in MeCN/DCM (1.7 mL / 1 mL respectively) was oxidized with (*S,S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), acetic acid (259  $\mu$ L, 4.53 mmol, 15 equiv.), and H<sub>2</sub>O<sub>2</sub> (34  $\mu$ L, 0.604 mmol, 2 equiv.) in 4:1 MeCN/DCM (2.8 mL/0.7 mL), at 0 °C and via the single addition protocol. Following oxidation, the crude was subjected to DAST (40  $\mu$ L, 0.303 mmol, 1.0 equiv.) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL 0%  $\rightarrow$  5%  $\rightarrow$  10% ethyl acetate in hexanes) to afford the desired product as a pale yellow oil.

**Run 1**: 63.8 mg, 0.208 mmol, 69% yield; 5% rsm by <sup>1</sup>H NMR.

**Run 2**: 71.2 mg, 0.232 mmol, 77% yield; 5% rsm by <sup>1</sup>H NMR.

**Run 3**: 70.2 mg, 0.230 mmol, 76% yield; 5% rsm by <sup>1</sup>H NMR.

Average overall yield: 74% yield (5% rsm)  $\pm$  3.6.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.54 (d, *J* = 2.1 Hz, 1H), 7.23 (d, *J* = 2.0 Hz, 1H), 4.98 (q, *J* = 6.5 Hz, 1H), 4.05 (ddd, *J* = 11.7, 9.4, 4.2 Hz, 1H), 3.83 (ddd, *J* = 11.6, 5.9, 3.6 Hz, 1H), 2.91 (m, 1H), 2.71 (dt, *J* = 16.5, 4.0 Hz, 1H), 1.55 (d, *J* = 6.5 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 137.95, 137.72, 133.31, 131.25, 121.86, 120.34, 71.18, 58.83, 28.66, 19.66 <u>HRMS:</u> (ESI TOF MS ES+)

*m/z* calculated for C<sub>10</sub>H<sub>9</sub>Br<sub>2</sub>O [M-H]: 302.9020, found 302.9013.



# V. Preparation and characterization of newly reported starting materials for Figure 4



trans-6-cyano-2,2-dimethyl-4-(2-oxopyrrolidin-1-yl)chroman-3-yl acetate [(±)-S30] In a 100-mL round-bottom flask were added 2,2-dimethyl-4a,8a-dihydro-2H-chromene-6-carbonitrile (878 mg, 4.74 mmol, 1.0 equiv) and CH<sub>2</sub>Cl<sub>2</sub> (18 mL). The solution was placed into an ice bath, and mCPBA (70 wt%, 1.4 g, 5.69 mmol, 1.2 equiv.) was added in one portion. The reaction was stirred overnight and guenched with sat. Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and then sat. NaHCO<sub>3</sub>. Purification by flash column chromatography (50 mL silica, 200 mL 20% $\rightarrow$ 30% EtOAc/Hex) afforded 2,2-dimethyl-1a,7b-dihydro-2*H*-oxireno[2,3-*c*]chromene-6carbonitrile **S29** as a pale-white oil (954 mg, 4.74 mmol, quantitative yield). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): δ 7.65 (d, J = 2.1 Hz, 1H), 7.53 (dd, J = 8.5, 2.1 Hz, 1H), 6.87 (d, J = 8.5 Hz, 1H), 3.91 (d, J = 4.4 Hz, 1H), 3.54 (d, J = 4.3 Hz, 1H), 1.60 (s, 3H), 1.30 (s, 3H). In a 100-mL round-bottom flask carrying **S28** was added 2-pyrrolidinone (403 mg, 4.74 mmol, 1.0 equiv.) and DMSO (28 mL). NaH (60 wt%, 190 mg, 4.74 mmol, 1.0 equiv.) was then added upon stirring. The reaction was stirred for 6 h, guenched with water, and extracted with EtOAc 3x. The organic layer was washed with water 2x and brine 1x, and dried over MgSO<sub>4</sub>. Purification by medium-pressure liquid chromatography (40 g silica, 50 column volumes 40%→100% EtOAc/Hex→10 column volumes EtOAc) afforded trans-3-hydroxy-2,2-dimethyl-4-(2oxopyrrolidin-1-yl)chromane-6-carbonitrile (±)-S29 as a white powder (755 mg, 2.64 mmol, 55% yield). <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>): 7.44 (dd, J = 8.5, 2.1 Hz, 1H), 7.23 (s, 1H), 6.87 (d, J = 8.5 Hz, 1H), 5.23 (d, J = 10.4 Hz, 1H), 4.11 (d, J = 6.8 Hz, 1H), 3.74 (dd, J = 10.4, 6.6 Hz, 1H), 3.37 (dt, J = 9.5, 7.6 Hz, 1H), 3.74 (dd, J = 10.4, 6.6 Hz, 1H), 3.37 (dt, J = 9.5, 7.6 Hz, 1H), 3.74 (dd, J = 10.4, 6.6 Hz, 1H), 3.87 (dt, J = 9.5, 7.6 Hz, 1H), 3.88 (dt, J = 10.4, 6.6 Hz, 1H), 3.87 (dt, J = 9.5, 7.6 Hz, 1H), 3.88 (dt, J = 10.4, 6.6 Hz, 1H), 3.87 (dt, J = 9.5, 7.6 Hz, 1H), 3.88 (dt, J = 10.4, 6.6 1H), 3.04 (td, J = 8.9, 4.4 Hz, 1H), 2.62 - 2.51 (m, 2H), 2.21 - 2.01 (m, 2H), 1.53 (s, 3H), 1.27 (s, 3H). In a 100-mL round-bottom flask carrying S29 (385 mg, 1.34 mmol, 1.0 equiv.) was added DMAP (16.4 mg, 0.134 mmol, 0.1 equiv.), CH<sub>2</sub>Cl<sub>2</sub> (10 mL), Et<sub>3</sub>N (934 µL, 678 mg, 6.70 mmol, 5.0 equiv.), and Ac<sub>2</sub>O (380  $\mu$ L, 410 mg, 4.02 mmol, 3.0 equiv.). The reaction was stirred overnight, and then quenched with sat. NaHCO<sub>3</sub>. The aqueous layer was extracted with  $CH_2Cl_2$  2x and the organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flash chromatography (50 mL silica, 300 mL  $40\% \rightarrow 60\%$  EtOAc/Hex) afforded the product as a white powder (326 mg, 0.99 mmol, 74% yield). <sup>1</sup>H NMR: (500 MHz, CDCl<sub>3</sub>)

δ 7.48 (dd, *J* = 8.5, 2.0 Hz, 1H), 7.26 (s, 1H), 6.93 (d, *J* = 8.5 Hz, 1H), 5.46 (d, *J* = 10.1 Hz, 1H), 5.15 (d, *J* = 10.1 Hz, 1H), 3.37 (dt, *J* = 9.3, 7.3 Hz, 1H), 2.93 (dt, *J* = 9.2, 6.7 Hz, 1H), 2.53 (dt, *J* = 17.1, 7.6 Hz, 1H), 2.41 (dt, *J* = 17.0, 8.4 Hz, 1H), 2.11 (s, 3H), 2.01 (p, *J* = 7.5 Hz, 2H), 1.43 (s, 3H), 1.35 (s, 3H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 176.97, 170.40, 157.15, 133.40, 132.02, 120.56, 119.14, 118.88, 105.02, 78.66, 69.80, 49.72, 42.60, 31.20, 26.39, 21.02, 19.63, 18.32

# HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>21</sub>N<sub>2</sub>O<sub>4</sub> [M+H]<sup>+</sup>: 329.1501, found 329.1511.



**methyl 2-(4-(1-oxoisoindolin-2-yl)phenyl)propanoate [S31]** Prepared according to literature and the NMR data matched those reported<sup>17</sup>.



methyl 2-(3-chloro-4-(1-oxoisoindolin-2-yl)phenyl)propanoate [S32] In a 50-mL recovery flask was added methyl 2-(4-(1-oxoisoindolin-2-yl)phenyl)propanoate S31 (713 mg, 2.41 mmol, 1.0 equiv.), toluene (12 mL), trifluoroacetic acid (92  $\mu$ L, 137 mg, 1.21 mmol, 0.5 equiv.), and *N*-chlorosuccinimide (484 mg, 3.62 mmol, 1.5 equiv.). The reaction was stirred at room temperature overnight, quenched with NaHCO<sub>3</sub>, and extracted with CH<sub>2</sub>Cl<sub>2</sub> 3x. The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by medium-pressure liquid chromatography (40 g silica, 55 column volumes 0% $\rightarrow$ 50% EtOAc/Hex) afforded the product as a white powder (544 mg, 1.65 mmol, 68% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.96 (dt, *J* = 7.7, 1.0 Hz, 1H), 7.62 (td, *J* = 7.5, 1.2 Hz, 1H), 7.56 – 7.49 (m, 2H), 7.48 (d, *J* = 2.0 Hz, 1H), 7.39 (d, *J* = 8.2 Hz, 1H), 7.31 (dd, *J* = 8.2, 2.0 Hz, 1H), 4.80 (s, 2H), 3.75 (q, *J* = 7.2 Hz, 1H), 3.71 (s, 3H), 1.53 (d, *J* = 7.2 Hz, 3H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.26, 168.29, 142.12, 141.77, 134.90, 132.81, 132.16, 132.04, 130.19, 129.85, 128.41, 127.25, 124.62, 123.01, 52.46, 52.35, 45.04, 18.60

 $\underline{IR:}$  (cm<sup>-1</sup>)

2955, 1733, 1683, 1500, 1469, 1447, 1433, 1399, 1336, 1302, 1255, 1212, 1197, 1168, 1100,

1078, 1046, 1016, 972, 921, 895, 867, 838, 800, 784, 758, 735, 682, 609, 578, 510, 484, 455 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>17</sub>NO<sub>3</sub>Cl [M+H]<sup>+</sup>: 330.0897, found 330.0897.

**8-phenethyl-1-oxa-3,8-diazaspiro**[**4.5**]**decan-2-one** [**S33**] Purchased from Sigma Aldrich as the hydrochloride salt.



(*S*)-2-methyl-3-((1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methoxy)pyridine [S34] According to the general procedure for nosyl protection, L-prolinol (425 mg, 4.20 mmol, 1 equiv.) was reacted with DMAP (51.3 mg, 0.420 mmol, 0.1 equiv.), Et<sub>3</sub>N (644  $\mu$ L, 467 mg, 4.62 mmol, 1.1 equiv.), and NsCl (1.02 g, 4.62 mmol, 1.1 equiv.) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elusion 200 mL 2% $\rightarrow$ 5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to afford (*S*)-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methanol with minor byproducts (roughly 970 mg, 3.39 mmol, 81% yield). In a separate 100-mL recovery flask triphenylphosphine (1.34 g, 5.09 mmol, 1.5 equiv.) and THF (13 mL) were added. The reaction was cooled to 0 °C, where DEAD (799  $\mu$ L, 886 mg, 5.09 mmol, 1.5 equiv.) was added dropwise, and the reaction was stirred for 30 min. (*S*)-(1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methanol and 2-methylpyridin-3-ol (555 mg, 5.09 mmol, 1.5 equiv.) in THF (5 mL) were then both added to the reaction mixture, and the reaction was stirred overnight at room temperature. The solvent was removed in vacuo, and the brown crude was repeatedly washed with hexanes and then CH<sub>2</sub>Cl<sub>2</sub>. The CH<sub>2</sub>Cl<sub>2</sub> wash was recrystallized by slowly evaporating CH<sub>2</sub>Cl<sub>2</sub> in the fume hood, and the resulting crystals were washed with EtOAc 3x to afford the product as off-white crystals (434 mg, 1.15 mmol, 23% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 8.8 Hz, 2H), 8.11 (dd, *J* = 4.5, 1.7 Hz, 1H), 8.03 (d, *J* = 8.8 Hz, 2H), 7.21-7.06 (m, *J* = 2H), 4.30 – 4.20 (m, 1H), 4.06 – 3.96 (m, 2H), 3.59 (ddd, *J* = 10.7, 7.1, 4.0 Hz, 1H), 3.26 – 3.17 (m, 1H), 2.43 (s, 3H), 2.14 – 1.98 (m, 2H), 1.85 – 1.67 (m, 2H).

 $\frac{13}{C}$  NMR: (126 MHz, CDCl<sub>3</sub>)

δ 152.64, 150.33, 148.68, 143.27, 141.06, 128.70, 124.58, 121.96, 117.50, 69.69, 58.87, 49.65, 29.13, 24.28, 19.62

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>20</sub>N<sub>3</sub>O<sub>5</sub>S [M+H]<sup>+</sup>: 378.1124, found 378.1116.

 $[\alpha]_D^{24} = -149.7^{\circ} (c = 1.00, CH_2Cl_2)$ 



4-(3,4-dichlorophenyl)-7-methoxy-2-(phenylsulfonyl)-1,2,3,4-tetrahydroisoquinoline **[S35]** Diclofensine was synthesized according to literature precedent<sup>18</sup>. Diclofensine (3.48 g, 10.8 mmol, 1 eq) was dissolved in dry 1,2-dichloroethane (0.3 M) at 0 °C. Proton sponge (2.31 g, 10.8 mmol, 1 eq) was added, followed by 1-chloroethyl chloroformate (2.33 mL, 21.6 mmol, 2 eq). The solution was stirred at 0 °C for 15 min before being refluxed for 3 hours. After that, the solution was concentrated *in vacuo*, filtered through a silica plug, and rinsed with 100 mL 1:1:1 hexane/EtOAc/DCM. The yellow solution was concentrated in vacuo, dissolved in methanol (0.3 M) and refluxed for 3 hours. The solution was then concentrated *in vacuo* and neutralized using sat. NaHCO<sub>3</sub> (20 mL). The aqueous layer was extracted with EtOAc (2 x 10 mL), the combined organics were dried under Na<sub>2</sub>SO<sub>3</sub> and concentrated in vacuo. Part of the resulting yellow oil (710 mg, 2.3 mmol, 1 eq) was dissolved in DCM (0.3 M). Triethylamine (705  $\mu$ L, 5.1 mmol, 2.2 eq), DMAP (28 mg, 0.23 mmol, 0.1 eq) and phenylsulfonyl chloride (590 µL, 4.6 mmol, 2 eq) were added respectively. The solution was stirred for 12 hours before being quenched with sat. NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted with DCM (3 x 10 mL). The combined organics were dried under Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting brown oil by flash chromatography (100 mL silica, DCM loaded, gradient elution 300 mL  $0\% \rightarrow 10\% \rightarrow 15\% \rightarrow 20\%$  EtOAc/Hex) to afford the desired product as a yellow solid in 93% yield (959 mg, 2.14 mmol).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.74 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.59 (t, *J* = 8.1 Hz, 1H), 7.51 (d, *J* = 8.1 Hz, 2H), 7.32 (d, *J* = 8.3 Hz, 1H), 7.12 (d, *J* = 2.1 Hz, 1H), 6.94 (dd, *J* = 8.3, 2.1 Hz, 1H), 6.77 (d, *J* = 8.5 Hz, 1H), 6.70 (dd, *J* = 8.6, 2.6 Hz, 1H), 6.64 (d, *J* = 2.6 Hz, 1H), 4.37 (d, *J* = 15.1 Hz, 1H), 4.30 (d, J = 15.1 Hz, 1H), 4.30 (

1H), 4.17 (t, *J* = 5.8 Hz, 1H), 3.77 (s, 3H), 3.61 (dd, *J* = 12.0, 4.9 Hz, 1H), 3.22 (dd, *J* = 12.0, 6.6 Hz, 1H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 158.68, 143.36, 136.43, 133.21, 133.08, 132.62, 131.20, 130.75, 130.69, 130.59, 129.25, 128.29, 127.73, 127.02, 114.04, 110.90, 55.44, 50.93, 47.99, 43.76.

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>22</sub>H<sub>20</sub>Cl<sub>2</sub>NO<sub>3</sub>S [M+H]<sup>+</sup>: 448.0541, found 448.0532.



1-(3-(dimethylamino)propyl)-1-(4-fluorophenyl)-1,3-dihydroisobenzofuran-5-carbonitrile[S36]Purchased from Sigma Aldrich as the hydrobromide salt.[S36]



*rel*-(6*R*,10*bR*)-9-chloro-6-(4-chlorophenyl)-2,3,6,10b-tetrahydropyrrolo[2,1-*a*]isoquinolin-5(1*H*)-one [S37] According to literature<sup>19</sup>, in a 100-mL round-bottom flask were added 2-(3-chlorophenyl)pyrrolidine (910 mg, 5.01 mmol, 1.0 equiv.), 4-chloromandelic acid (934 mg, 5.01 mmol, 1.0 equiv.), and xylene (15 mL). A Dean-Stark trap and reflux condenser were placed on top of the flask. The reaction was refluxed for 40 h, and the solvent was removed in vacuo. PPA (7.5 mL) was then added to the flask, and the flask was placed into a 100 °C oil bath and heated for 1.5 h. Upon completion, water (25 mL) was added and the aqueous layer was extracted with  $CH_2Cl_2$  3x. The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flask chromatography (75 mL silica, 300 mL 30% EtOAc/Hex) followed by medium-pressure liquid chromatography (40 g silica, 60 column volumes 0% $\rightarrow$ 40% EtOAc/Hex) afforded the product as a light yellow foam (170 mg, 0.51 mmol, 10% yield). Stereochemistry was assigned by <sup>1</sup>H NMR, COSY, and NOESY 1D methods. <sup>1</sup>H NMR: (500 MHz, CDCl<sub>3</sub>)

δ 7.34 (dd, *J* = 8.1, 2.1 Hz, 1H), 7.28 (s, 1H), 7.22 (d, *J* = 8.5 Hz, 2H), 7.17 (d, *J* = 8.1 Hz, 1H), 7.04 (d, *J* = 8.5 Hz, 2H), 4.84 (s, 1H), 4.47 (dd, *J* = 10.1, 5.8 Hz, 1H), 3.65 – 3.50 (m, 2H), 2.63-2.57 (m, 1H), 2.19 – 2.09 (m, 1H), 2.00 – 1.86 (m, 2H) <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 167.85, 138.84, 136.06, 133.95, 133.64, 133.43, 130.00, 128.97, 128.74, 128.60, 125.01, 58.77, 53.24, 45.49, 31.71, 23.06

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>16</sub>NOCl<sub>2</sub> [M+H]<sup>+</sup>: 332.0609, found 332.0604.



For COSY and NOESY see Supporting Information: Spectral Data



(*R*)-(3-(4-bromo-3-fluorophenyl)-2-oxooxazolidin-5-yl)methyl acetate [S38] In a 100-mL recovery flask were added (*R*)-3-(4-bromo-3-fluorophenyl)-5-(hydroxymethyl)oxazolidin-2-one (Aldrich, 1.00 g, 3.45 mmol, 1.0 equiv.), DMAP (42 mg, 0.345 mmol, 0.1 equiv.), CH<sub>2</sub>Cl<sub>2</sub> (20 mL), Et<sub>3</sub>N (2.4 mL, 1.74 g, 17.2 mmol, 5 equiv.), and Ac<sub>2</sub>O (978  $\mu$ L, 1.06 g, 10.4 mmol, 3.0 equiv.). The reaction was stirred overnight, and partitioned between sat. NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> 3x. The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flask chromatography (55 mL silica, 300 mL 50% EtOAc/Hex) afforded the product as a white solid (1.10 g, 3.33 mmol, 97% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.56 – 7.53 (m, 1H), 7.53-7.50 (m, 1H), 7.16 (ddt, *J* = 8.9, 2.3, 1.1 Hz, 1H), 4.89 (dddd, *J* = 8.8, 6.2, 4.9, 3.9 Hz, 1H), 4.38 (dd, *J* = 12.3, 3.9 Hz, 1H), 4.31 (dd, *J* = 12.3, 4.9 Hz, 1H), 4.10 (t, *J* = 9.0 Hz, 1H), 3.80 (dd, *J* = 8.9, 6.3 Hz, 1H), 2.10 (s, 3H).

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.62, 159.35 (d, *J* = 246.6 Hz), 153.79, 138.80 (d, *J* = 9.7 Hz), 133.73 (d, *J* = 1.8 Hz), 114.46 (d, *J* = 3.4 Hz), 106.86 (d, *J* = 27.9 Hz), 103.64 (d, *J* = 21.1 Hz), 70.16, 64.02, 47.00, 20.78

<sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

δ -104.51 (dd, *J* = 10.9, 7.4 Hz) <u>HRMS:</u> (ESI-TOF MS ES+) m/z calculated for C<sub>12</sub>H<sub>12</sub>NO<sub>4</sub>FBr [M+H]<sup>+</sup>: 331.9934, found 331.9943. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -48.2° (c = 0.91, CH<sub>2</sub>Cl<sub>2</sub>)



((3*S*,4*R*)-4-(4-fluorophenyl)-1-((4-nitrophenyl)sulfonyl)piperidin-3-yl)methyl acetate [S39] ((3*S*,4*R*)-4-(4-fluorophenyl)piperidin-3-yl)methanol (210 mg, 1.0 mmol, 1 eq) was dissolved in DCM (4 mL, 0.25 M). DMAP (12 mg, 0.10 mmol, 0.10 eq) and nosyl chloride (243 mg, 1.10 mmol, 1.1 eq) were added respectively. Triethylamine (153 µL, 1.10 mmol, 1.1 eq) was added last and the solution was stirred for 12 hours before being diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted three times with DCM (3x10 mL), and the combined organics were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting oil was dissolved in DCM (4 mL, 0.4 M), and DMAP (12 mg, 0.10 mmol, 0.1 eq), acetic anhydride (473 µL, 5.00 mmol, 5 eq), and triethylamine (418 µL, 3.00 mmol, 3 eq) were added in that order. The solution was stirred overnight before being diluted with 1M NaOH (10 mL) and DCM (10 mL). The aqueous layer was extracted with DCM (3x10 mL), and the combined organics were dried with 1M NaOH (10 mL) and DCM (10 mL). The aqueous layer was extracted with DCM (3x10 mL), and the combined organics were dried with 1M NaOH (10 mL) and DCM (10 mL). The aqueous layer was extracted with DCM (3x10 mL), and the combined organics were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated *in vacuo*. The resulting crude was purified by flash chromatography (75 mL silica, dry loaded, gradient elution 300 mL 5%  $\rightarrow$  10%  $\rightarrow$  15%  $\rightarrow$  20%  $\rightarrow$  25%  $\rightarrow$  30% EtOAc/Hex) to afford the desired product as a pale white powder (349.1 mg, 0.800 mmol, 80% yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.42 (d, *J* = 8.9 Hz, 2H), 7.99 (d, *J* = 8.9 Hz, 2H), 7.07 (ddd, *J* = 8.2, 5.3, 2.5 Hz, 2H), 7.00 (t, *J* = 8.6 Hz, 2H), 4.09 (dt, *J* = 10.3, 2.6 Hz, 1H), 3.98 (dt, *J* = 11.1, 2.7 Hz, 1H), 3.82 (dd, *J* = 11.4, 2.5 Hz, 1H), 3.58 (dd, *J* = 11.6, 7.0 Hz, 1H), 2.44 – 2.35 (m, 1H), 2.33 – 2.17 (m, 3H), 2.00 (s, 3H), 1.94 – 1.84 (m, 2H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-d)

δ 170.80, 162.01 (d, *J* = 245.7 Hz), 150.42, 142.40, 137.59 (d, *J* = 3.3 Hz), 128.96, 128.72 (d, *J* = 7.9 Hz), 124.59, 116.02 (d, *J* = 21.3 Hz), 64.34, 49.50, 46.78, 43.86, 40.98, 33.71, 20.92.

<sup>19</sup>F NMR: (471 MHz, Chloroform-*d*)

δ -115.14 (tt, J = 8.0, 5.2 Hz).

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>20</sub>H<sub>21</sub>FN<sub>2</sub>NaO<sub>6</sub>S [M+Na]<sup>+</sup>: 459.1002, found 459.1005.

 $[\alpha]_D^{24} = -52.9 \ (c = 1.00, EtOH)$ 



**1-((4-(5-(***p***-tolyl)-3-(trifluoromethyl)-1***H***-pyrazol-1-yl)phenyl)sulfonyl)piperidine [S40] Celecoxib (1.53g, 4.00 mmol, 1 eq) and K<sub>2</sub>CO<sub>3</sub> (553 mg, 4 mmol, 1 eq) were dissolved in acetone (10 mL, 0.4 M). 1,5 dibromopentane (544 \muL, 4 mmol, 1 eq) was added. The solution was refluxed for 3 hours after which another equivalent of K<sub>2</sub>CO<sub>3</sub> was added. The solution was refluxed overnight. The solution was then concentrated** *in vacuo***, diluted with EtOAc (15 mL) and 1M NaOH (10 mL). The aqueous layer was extracted with EtOAc (3x10 mL), and the combined organics were dried with Na<sub>2</sub>SO<sub>3</sub> and concentrated** *in vacuo***. The crude product was purified by flash chromatography (175 mL silica, dry loaded, gradient elution 300 mL 0% \rightarrow 2.5 L 10% EtOAc/Hex) to afford the desired product as a white solid in 72% yield (1.29 g, 2.86 mmol).** 

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.74 (d, *J* = 8.5 Hz, 2H), 7.48 (d, *J* = 8.6 Hz, 2H), 7.17 (d, *J* = 7.9 Hz, 2H), 7.09 (d, *J* = 8.2 Hz, 2H), 6.75 (s, 1H), 2.98 (t, *J* = 5.5 Hz, 4H), 2.38 (s, 3H), 1.63 (p, *J* = 5.7 Hz, 4H), 1.43 (p, *J* = 5.6, 5.1 Hz, 2H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 145.41, 144.22 (q, J = 38.6 Hz), 142.57, 139.92, 136.19, 129.84, 128.81, 128.71, 125.75, 125.60, 121.17 (q, J = 269.1 Hz), 106.27 (d, J = 2.0 Hz), 47.03, 25.23, 23.59, 21.43

<sup>19</sup>F NMR: (470 MHz, Chloroform-*d*)

δ-62.45

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>22</sub>H<sub>23</sub>F<sub>3</sub>N<sub>3</sub>O<sub>2</sub>S [M+H]<sup>+</sup>: 450.1463, found 450.1456.

**methyl ((4-nitrophenyl)sulfonyl)-***L***-prolyl-***L***-alaninate [S41]** In a 500-mL round-bottom flask were added ((4-nitrophenyl)sulfonyl)-*L***-proline**<sup>5</sup> (4.53 g, 15.1 mmol, 1 equiv.), *L***-alanine** methyl ester hydrochloride (2.11 g, 15.1 mmol, 1 equiv.), and  $CH_2Cl_2$  (160 mL). The mixture was cooled to 0 °C, and DIPEA (2.63 mL, 1.95 g, 15.1 mmol, 1 equiv.) was added dropwise, followed by HOBt (80 wt%, 2.81 g, 16.6 mmol, 1.1 equiv.) and EDC (2.34 g, 15.1 mmol, 1 equiv.). The mixture was then taken out of the ice

bath and stirred overnight, and washed with 10% citric acid, brine, and sat. NaHCO<sub>3</sub>. The organic layer was dried over MgSO<sub>4</sub> and condensed in vacuo. Purification by medium-pressure liquid chromatography (40 g silica, 15 column volumes  $0\% \rightarrow 5\% \rightarrow 10$  column volumes 5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) afforded the product as a pale yellow powder (2.62 g, 6.81 mmol, 45% yield).

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.40 (d, *J* = 8.8 Hz, 2H), 8.08 (d, *J* = 8.8 Hz, 2H), 7.13 (d, *J* = 7.2 Hz, 1H), 4.55 (p, *J* = 7.2 Hz, 1H), 4.19 (dd, *J* = 8.5, 2.9 Hz, 1H), 3.78 (s, 3H), 3.58 (ddd, *J* = 10.8, 7.4, 3.4 Hz, 1H), 3.27 (dd, *J* = 9.4, 6.6 Hz, 1H), 2.27-2.19 (m, 1H), 1.94-1.81 (m, 1H), 1.81-1.67 (m, 2H), 1.45 (d, *J* = 7.2 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 172.94, 170.23, 150.63, 142.53, 129.21, 124.66, 62.47, 52.76, 49.86, 48.56, 30.37, 24.71, 18.48

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>15</sub>H<sub>20</sub>N<sub>3</sub>O<sub>7</sub>S [M+H]<sup>+</sup>: 386.1022, found 386.1020.

 $[\alpha]_{D}^{24} = -120.9^{\circ} (c = 1.15, CH_2Cl_2)$ 



**methyl** ((4-nitrophenyl)sulfonyl)-*L*-prolyl-*L*-leucyl-*L*-alaninate [S42] Prepared according to the general procedure for peptide couplings as reported in literature and the NMR data matched those reported<sup>5</sup>.



5-(*tert*-butyl) 1-methyl ((4-nitrophenyl)sulfonyl)-*L*-prolyl-*L*-leucyl-*L*-alanyl-*L*-glutamate [S43] Prepared according to the general procedure for peptide couplings as reported in literature<sup>5</sup>. <u><sup>1</sup>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.47 (d, *J* = 8.8 Hz, 2H), 8.13 (d, *J* = 8.8 Hz, 2H), 7.01 (d, *J* = 7.9 Hz, 1H), 6.93 (d, *J* = 7.8 Hz, 1H), 6.82 (d, *J* = 7.7 Hz, 1H), 4.58 – 4.50 (m, 2H), 4.46 (ddd, *J* = 9.9, 7.7, 4.4 Hz, 1H), 4.06 (dd, *J* = 9.0, 4.2 Hz, 1H), 3.75 (s, 3H), 3.72 (ddd, *J* = 10.5, 6.7, 4.2 Hz, 1H), 3.19 (ddd, *J* =

10.0, 8.4, 6.6 Hz, 1H), 2.42 – 2.26 (m, 2H), 2.21 – 1.79 (m, 5H), 1.76 – 1.60 (m, 4H), 1.44 (s, 9H), 1.40 (d, *J* = 7.2 Hz, 3H), 1.00 (d, *J* = 6.3 Hz, 3H), 0.95 (d, *J* = 6.3 Hz, 3H) <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 172.31, 172.07, 172.05, 171.44, 171.40, 150.97, 140.45, 129.63, 124.99, 80.94, 62.80, 52.88, 52.60, 51.99, 50.37, 48.97, 40.37, 31.85, 31.22, 28.23, 27.51, 25.50, 24.81, 23.25, 21.56, 17.47 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>30</sub>H<sub>46</sub>N<sub>5</sub>O<sub>11</sub>S [M+H]<sup>+</sup>: 684.2915, found 684.2917. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -99.8° (c = 1.22, CH<sub>2</sub>Cl<sub>2</sub>)



(3a*R*,5a*S*,9a*S*)-3a,6,6,9a-tetramethyldodecahydronaphtho[2,1-*b*]furan [S44] Purchased from Sigma Aldrich.



**2-(4-bromo-2-fluorobenzyl)-6-phenyl-1,2-thiazinane 1,1-dioxide [46]** Prepared according to literature procedures<sup>20</sup>.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.49 – 7.45 (m, 2H), 7.44 – 7.35 (m, 4H), 7.33 (dd, J = 8.3, 1.8 Hz, 1H), 7.27 (m, 1H), 4.49 (d, J = 15.0 Hz, 1H), 4.43 (d, J = 15.0 Hz, 1H), 4.10 (dd, J = 12.9, 3.3 Hz, 1H), 3.66 (td, J = 13.6, 2.8 Hz, 1H), 3.16 (m, 1H), 2.66 (qd, J = 13.2, 3.7 Hz, 1H), 2.26 (dp, J = 13.8, 3.3 Hz, 1H), 1.92 (qt, J = 13.1, 4.0 Hz, 1H), 1.79 (dp, J = 14.4, 3.1 Hz, 1H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 160.96 (d, *J* = 251.0 Hz), 132.23, 132.19 (d, *J* = 2.2 Hz), 129.62, 129.14, 128.89, 128.08 (d, *J* = 3.7 Hz), 122.94 (d, J = 14.3 Hz), 122.17 (d, J = 9.5 Hz), 119.21 (d, J = 25.0 Hz), 65.05, 49.14, 44.22, 31.04, 23.04.

<sup>19</sup>F NMR: (471 MHz, Chloroform-*d*)

δ -116.28 (t, J = 8.8 Hz).



(R)-(3-(3-fluoro-4-(6-(2-methyl-2H-tetrazol-5-yl)pyridin-3-yl)phenyl)-2-oxooxazolidin-5-yl)methyl acetate [48] In a 50-mL recovery flask were added (R)-3-(4-bromo-3-fluorophenyl)-5-(hydroxymethyl)oxazolidin-2-one (Aldrich, 500 mg, 1.72 mmol, 1.0 equiv.), B<sub>2</sub>Pin<sub>2</sub> (875 mg, 3.45 mmol, 2.0 equiv.), Pd(dppf)Cl2•CH2Cl2 (70.2 mg, 0.086 mmol, 0.05 equiv.), and KOAc (677 mg, 6.90 mmol, 4.0 equiv.). The flask was backfilled with nitrogen 3x, and DMSO (5 mL) was added. The septa was quickly replaced by a yellow polyethylene cap, and the joint was secured with parafilm. The reaction was placed in 80 °C oil bath and stirred overnight. Upon completion, the reaction mixture was partitioned between EtOAc and water. The aqueous layer was extracted with EtOAc 2x, and the organic layers were combined, washed with brine 3x, dried over MgSO<sub>4</sub>, and condensed in vacuo. 5-(4-bromophenyl)-2methyl-2H-tetrazole (413 mg, 1.72 mmol, 1.0 equiv.), Pd(dppf)Cl<sub>2</sub>•CH<sub>2</sub>Cl<sub>2</sub> (28.1 mg, 0.034 mmol, 0.02 equiv.), and cesium carbonate (1.68 g, 5.16 mmol, 3.0 equiv.) were added to the crude, and the flask was backfilled with nitrogen 3x. Water (2.6 mL) and dioxane (5.2 mL) were added, and the septa was quickly replaced by a polyethylene yellow cap. The reaction mixture was heated at 70 °C while stirring overnight. Upon completion, the reaction mixture was partitioned between EtOAc and water. A large amount of offwhite precipitate formed and was collected through filtration. The aqueous layer was extracted with EtOAc 2x, and the organic layers were combined with the solid, and condensed in vacuo. The resulting crude was triturated 3x with EtOAc, and the remaining solid was mixed with CH<sub>2</sub>Cl<sub>2</sub> (10.3 mL), DMAP (21.0 mg, 0.172 mmol, 0.1 equiv.), Et<sub>3</sub>N (1.2 mL, 870 mg, 8.60 mmol, 5.0 equiv.), and Ac<sub>2</sub>O (488 μL, 527 mg, 5.16 mmol, 3.0 equiv.) were added. The reaction was stirred overnight, and partitioned between  $CH_2Cl_2$  and sat. NaHCO<sub>3</sub>. The aqueous layer was extracted with  $CH_2Cl_2$  3x, and the organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. Purification by flash chromatography (50 mL silica, gradient elution 300 mL 80%→600 mL 100% EtOAc/Hex) followed by twice trituration of the resulting solid with 25% EtOAc/Hex afforded the product as a pale pink powder (383 mg, 0.923 mmol, 54% overall yield).

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.94 (s, 1H), 8.31 (d, *J* = 8.1 Hz, 1H), 8.05 (d, *J* = 8.1 Hz, 1H), 7.62 (dd, *J* = 12.7, 2.0 Hz, 1H), 7.53 (t, *J* = 8.4 Hz, 1H), 7.40 (dd, *J* = 8.4, 2.3 Hz, 1H), 4.93 (dq, *J* = 9.7, 5.2 Hz, 1H), 4.47 (s, 3H), 4.42 (dd, *J* = 12.3, 3.8 Hz, 1H), 4.34 (dd, *J* = 12.3, 4.8 Hz, 1H), 4.18 (t, *J* = 8.9 Hz, 1H), 3.88 (dd, *J* = 8.9, 6.2 Hz, 1H), 2.12 (s, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.65, 164.87, 160.27 (d, *J* = 249.1 Hz), 153.87, 150.04 (d, *J* = 3.0 Hz), 145.72, 139.91 (d, *J* = 10.7 Hz), 137.22 (d, *J* = 3.1 Hz), 132.28, 130.82 (d, *J* = 4.6 Hz), 122.15, 120.61 (d, *J* = 13.7 Hz), 113.93 (d, *J* = 3.2 Hz), 106.54 (d, *J* = 28.4 Hz), 70.26, 64.08, 47.05, 39.90, 20.81

<sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

δ -114.34 (dd, J = 12.8, 8.3 Hz)

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>18</sub>N<sub>6</sub>O<sub>4</sub>F [M+H]<sup>+</sup>: 413.1374, found 413.1381.

 $[\alpha]_D^{24} = -49.4^{\circ} (c = 0.68, CH_2Cl_2)$ 







(3R,5S,8R,9S,10S,13S,14S,17S)-10,13-dimethyl-17-(pyridin-3-yl)hexadecahydro-1H-

**cyclopenta**[*a*]**phenanthren-3-yl acetate** [(+)-53] Prepared according to literature procedures and the NMR data matched those reported<sup>22</sup>.

## VI. Experimental procedures and compound characterization for Figure 4

**General procedures:** In Figure 4 the general procedures for C–H oxidation, BF<sub>3</sub>-promoted methylation, DAST-promoted methylation, and TFAA-promoted methylation were followed for all substrates unless otherwise specified.

General procedure for TFAA-promoted methylation: The crude from oxidation was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL, 0.2 M), backfilled with nitrogen 3x, and trifluoroacetic anhydride (41.7  $\mu$ L, 63.0 mg, 0.30 mmol, 1.0 equiv.) was added. The reaction was stirred at room temperature for 1 h, and then placed into a -78 °C dry ice/acetone bath. Trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.) and trimethylsilyl triflate (TMSOTf) (54.5  $\mu$ L, 66.7 mg, 0.30 mmol, 1.0 equiv.) were then added dropwise. The reaction mixture was stirred at -78 °C for 2 h, then allowed to warm to room temperature while stirring for 1 h. Upon completion, the reaction was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and poured into a 60 mL separatory funnel containing 3 mL 1 M NaOH for quenching. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over anhydrous MgSO<sub>4</sub>, filtered, and condensed in vacuo before subjecting to purification via flash or medium pressure chromatography.



*rel-(3S,4R)-6-cyano-2,2-dimethyl-4-(2-methyl-5-oxopyrrolidin-1-yl)chroman-3-yl* acetate [(±)-27] According to the general oxidation and DAST-promoted methylation procedures, *rel-(3S,4R)-6-cyano-2,2-dimethyl-4-(2-oxopyrrolidin-1-yl)chroman-3-yl* acetate **S30** (65.7 mg, 0.20 mmol, 1.0 equiv.) in MeCN (0.4 mL, 0.5 M) was oxidized with (*S,S)-Mn*(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.0075 equiv.), AcOH (172  $\mu$ L, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (57.7  $\mu$ L, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M). For facile product isolation, the oxidized products were isolated following oxidation by flash chromatography (dry loading, 50 mL silica, gradient elution 200 mL 20% $\rightarrow$ 30% $\rightarrow$ 50% EtOAc/CHCl<sub>3</sub>), and methylated with DAST (26.4  $\mu$ L, 32.2 mg, 0.20 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 300  $\mu$ L, 0.60 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, 300 mL 60% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers.

Run 1 (34.9 mg, 0.102 mmol, 51% yield, 1.6:1 dr; 18.0 mg, 0.0548 mmol, 27% rsm)

Run 2 (36.6 mg, 0.107 mmol, 53% yield, 2:1 dr; 21.7 mg, 0.0661 mmol, 33% rsm)

Run 3 (25.9 mg, 0.0756 mmol, 50% yield, 1.7:1 dr; 16.7 mg, 0.0508 mmol, 34% rsm) [0.15 mmol scale]

#### Average overall yield: 51% (31% rsm) ± 1.5, 1.8:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.50-7.40 (m, 1.36H), 7.23 (s, 0.64H), 6.94 (d, *J* = 8.5 Hz, 0.64H), 6.88 (d, *J* = 9.0 Hz, 0.36H), 5.70-5.16 (br m, 2H), 3.94 (sxt, *J* = 6.5 Hz, 0.36H), 3.56 (sxt, *J* = 6.5 Hz, 0.64H), 2.56 (ddd, *J* = 17.1, 10.0, 5.0 Hz, 0.36H), 2.51-2.39 (m, 1.28H), 2.34 (ddd, *J* = 17.3, 9.6, 8.2 Hz, 0.36H), 2.22-2.13 (m, 1H), 2.11 (s, 1.92H), 2.09 (s, 1.08H), 1.68-1.52 (m, 1H), 1.42 (s, 1.08H), 1.40 (s, 1.92H), 1.29 (m, 3H), 1.18 (br s, 1.92H), 0.73 (br d, *J* = 4.8 Hz, 1.08H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 177.10, 176.55, 170.34, 170.10, 157.06, 156.20, 133.10, 132.07, 123.98, 120.93, 119.27, 118.95, 118.87, 118.71, 104.73, 104.72, 79.10, 78.84, 72.38, 69.24, 53.56, 53.03, 50.24, 49.32, 30.38, 30.30, 27.92, 27.74, 26.48, 26.44, 21.93, 21.06, 21.02, 20.60, 19.35, 19.26

#### HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>23</sub>N<sub>2</sub>O<sub>4</sub> [M+H]<sup>+</sup>: 343.1658, found 343.1666.



*rel-(3S,4R)-3-hydroxy-2,2-dimethyl-4-(2-methyl-5-oxopyrrolidin-1-yl)chromane-6-carbonitrile* [( $\pm$ )-28] In a 25-mL round-bottom flask containing *rel-(3S,4R)-6-cyano-2,2-dimethyl-4-(2-methyl-5-oxopyrrolidin-1-yl)chroman-3-yl* acetate ( $\pm$ )-27 (38.1 mg, 0.102 mmol, 1.0 equiv.) was added 1 M NaOH in methanol (1 mL, 1 mmol, 10 equiv.). The reaction mixture was stirred for 1 h at room temperature and partitioned between water and CH<sub>2</sub>Cl<sub>2</sub> (5 mL each). The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (3x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, condensed in vacuo, and purified by flash chromatography (20 mL silica, 200 mL 80% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers (26.1 mg, 0.0869 mmol, 85% yield, 1.5:1 dr).

Characterization of major diastereomer:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.47 (d, *J* = 8.5 Hz, 1H), 7.26 (s, 1H), 6.92 (d, *J* = 8.5 Hz, 1H), 5.52-5.14 (br s, 1H), 3.99-3.80 (br s, 1H), 3.80-3.63 (br s, 1H), 3.63-3.40 (br s, 1H), 2.70-2.40 (br m, 2H), 2.31 (dq, *J* = 15.6, 7.7 Hz, 1H), 1.74 (td, *J* = 13.0, 5.8 Hz), 1.51 (s, 3H), 1.25 (s, 3H), 1.13 (br s, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 178.79, 157.69, 133.18, 131.96, 120.44, 119.26, 119.10, 104.22, 80.93, 74.62, 53.10, 30.27, 27.87, 26.67, 21.56, 18.11

#### HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>21</sub>N<sub>2</sub>O<sub>3</sub>S [M+H]<sup>+</sup>: 301.1552, found 301.1554.

Characterization of minor diastereomer:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.41 (dd, *J* = 8.5, 2.1 Hz, 1H), 7.39 (t, *J* = 1.5 Hz, 1H), 6.84 (d, *J* = 8.4 Hz, 1H), 5.17 (d, *J* = 10.6 Hz, 1H), 3.98 (m, 2H), 3.23 (br s, 1H), 2.61 (ddd, *J* = 17.2, 9.6, 4.7 Hz, 1H), 2.47 (ddd, *J* = 17.3, 9.8, 8.2 Hz, 1H), 2.31 (dddd, *J* = 12.5, 9.8, 7.4, 4.8 Hz, 1H), 1.73-1.65 (m, 1H), 1.56 (s, 3H), 1.25 (s, 3H), 0.85 (d, *J* = 6.3 Hz, 3H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 177.95, 156.55, 132.94, 132.58, 123.94, 119.22, 118.64, 104.07, 80.48, 69.21, 53.41, 51.78, 30.56, 27.51, 26.85, 22.25, 18.50

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>21</sub>N<sub>2</sub>O<sub>3</sub> [M+H]<sup>+</sup>: 301.1552, found 301.1555.



methyl 2-(4-(1-methyl-3-oxoisoindolin-2-yl)phenyl)propanoate [29] According to the general oxidation DAST-promoted methylation procedures, methyl 2-(4-(1-oxoisoindolin-2and vl)phenvl)propanoate **S31** (59.0 mg, 0.20 mmol, 1.0 equiv.) in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (0.4 mL, 0.5 M) was oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (5.4 mg, 0.004 mmol, 0.02 equiv.), AcOH (172 µL, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (57.7 µL, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M), and methylated with DAST (26.4 µL, 32.2 mg, 0.20 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 300 µL, 0.60 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, 300 mL 60% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers. The starting material was resubjected once to the oxidation and methylation conditions and the products were combined.

**Run 1** (1<sup>st</sup> cycle: 14.2 mg, 0.0459 mmol, 23% yield, 1:1 dr; 28.3 mg, 0.0958 mmol, 48% rsm. 2<sup>nd</sup> cycle: 6.4 mg, 0.0207 mmol, 22% yield, 1:1 dr; 16.3 mg, 0.0552 mmol, 58% rsm. Overall: 20.6 mg, 0.0666 mmol, 33% yield, 1:1 dr; 16.3 mg, 0.0552 mmol, 28% rsm)

**Run 2** (1<sup>st</sup> cycle: 13.0 mg, 0.0420 mmol, 21% yield, 1:1 dr; 37.3 mg, 0.126 mmol, 63% rsm. 2<sup>nd</sup> cycle: 8.2 mg, 0.0265 mmol, 21% yield, 1:1 dr; 19.2 mg, 0.0650 mmol, 51% rsm. Overall: 21.2 mg, 0.0685 mmol, 34% yield, 1:1 dr; 19.2 mg, 0.0650 mmol, 33% rsm)
**Run 3** (1<sup>st</sup> cycle: 10.3 mg, 0.0333 mmol, 17% yield, 1:1 dr; 39.7 mg, 0.134 mmol, 67% rsm. 2<sup>nd</sup> cycle: 8.9 mg, 0.0288 mmol, 22% yield, 1:1 dr; 19.5 mg, 0.0660 mmol, 49% rsm. Overall: 18.9 mg, 0.0611 mmol, 31% yield, 1:1 dr; 19.5 mg, 0.0660 mmol, 33% rsm)

# Average overall yield: 33% (31% rsm) ± 1.5, 1:1 dr

Oxidative methylation with (S,S)-Mn(CF<sub>3</sub>PDP) (0.10 equiv.): 7% yield, 16% rsm by <sup>1</sup>H NMR.

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.92 (d, *J* = 7.5 Hz, 1H), 7.61 (t, *J* = 7.5 Hz, 1H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.52 (d, *J* = 7.5 Hz, 1H), 7.49 (d, *J* = 7.5 Hz, 1H), 7.38 (d, *J* = 7.6 Hz, 2H), 5.19 (q, *J* = 6.7 Hz, 1H), 3.75 (app qd, *J* = 7.1, 2.6 Hz, 1H), 3.68 (app d, *J* = 2.7 Hz, 3H), 1.52 (app dd, *J* = 7.2, 4.8 Hz, 3H), 1.46 (d, *J* = 6.6 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 175.04, 167.05, 146.38, 137.59, 137.54, 136.19, 132.23, 131.86, 128.55, 128.38, 128.35, 124.29, 123.55, 122.10, 57.00, 52.24, 45.10, 45.08, 18.96, 18.71

<u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>20</sub>NO<sub>3</sub> [M+H]<sup>+</sup>: 310.1443, found 310.1446.

methyl 2-(3-chloro-4-(1-methyl-3-oxoisoindolin-2-yl)phenyl)propanoate [30] According to the general oxidation and DAST-promoted methylation procedures, methyl 2-(3-chloro-4-(1-oxoisoindolin-2-yl)phenyl)propanoate S32 (66.0 mg, 0.20 mmol, 1.0 equiv.) in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (0.4 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (5.4 mg, 0.004 mmol, 0.02 equiv.), AcOH (172  $\mu$ L, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (57.7  $\mu$ L, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M), and methylated with DAST (26.4  $\mu$ L, 32.2 mg, 0.20 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 300  $\mu$ L, 0.60 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, 300 mL 60% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers.

Run 1 (35.5 mg, 0.103 mmol, 52% yield, 1:1 dr; 5.0 mg, 0.015 mmol, 8% rsm)

Run 2 (39.4 mg, 0.115 mmol, 57% yield, 1:1 dr; 6.6 mg, 0.020 mmol, 10% rsm)

Run 3 (38.3 mg, 0.112 mmol, 56% yield, 1:1 dr; 8.3 mg, 0.025 mmol, 13% rsm)

Average overall yield: 55% (10% rsm) ± 2.7, 1:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.94 (d, *J* = 7.6 Hz, 1H), 7.62 (td, *J* = 7.5, 1.2 Hz, 1H), 7.55-7.45 (m, 3H), 7.30 (d, *J* = 2.8 Hz, 2H), 5.16-5.07 (m, 1H), 3.75 (app qd, *J* = 7.4, 2.3 Hz, 1H), 3.71 (s, 1.5H), 3.71 (s, 1.5H), 1.53 (app dd, *J* = 7.2, 2.4 Hz, 3H), 1.40 (d, *J* = 6.8 Hz, 3H)

## $\frac{13}{C}$ NMR: (126 MHz, CDCl<sub>3</sub>)

δ 174.27, 167.65, 147.36, 142.08, 142.05, 133.47, 132.25, 131.30, 129.92, 129.83, 128.44, 127.13, 127.06, 124.51, 122.25, 58.36, 52.46, 45.04, 18.80, 18.63

 $\underline{IR:}$  (cm<sup>-1</sup>)

2978, 2951, 1735, 1699, 1563, 1500, 1469, 1434, 1408, 1378, 1334, 1297, 1250, 1210, 1164,

1116, 1095, 1058, 1014, 972, 888, 862, 825, 793, 758, 718, 692, 610, 538

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>19</sub>NO<sub>3</sub>Cl [M+H]<sup>+</sup>: 344.1053, found 344.1048.

For HSQC and HMBC see Supporting Information: Spectral Data

4-methyl-8-phenethyl-1-oxa-3,8-diazaspiro[4.5]decan-2-one [31] Following the double-slow addition oxidation protocol and DAST-promoted procedures, fenspiride S33 (78.9 mg, 0.303 mmol, 1.00 eq) was dissolved in DCM under N<sub>2</sub>. HBF<sub>4</sub>•OEt<sub>2</sub> (46 µL, 0.333 mmol, 1.1 eq) was added and the solution was stirred for 1 h at RT before being concentrated in vacuo. The resulting white solid was dissolved in 2:1 MeCN/AcOH (1.2 mL). In a 1 mL syringe, (S,S)-Mn(PDP) (28.2 mg, 0.0303 mmol, 0.1 eq) was dissolved in MeCN (0.4 mL). In a 12 mL syringe,  $H_2O_2$  (35  $\mu$ L, 0.604 mmol, 2 eq, 50 wt.% in  $H_2O$ ) was dissolved in 2:1 MeCN/AcOH (3.5 mL, 0.4 M). Both syringe contents were added at 0 °C over the course of 1 h using a syringe pump. After NaOH workup to remove the HBF<sub>4</sub> salt, the resulting oil was purified by flash chromatography (75 mL silica, loaded with DCM, gradient elution 200 mL 4% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  6% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  8% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  10% MeOH/DCM with 1% NH4OH). The RSM was isolated, and the rest of the oxidized products were combined and taken on to the methylation. The RSM was resubmitted to the HBF<sub>4</sub> protection, and then the oxidation conditions. Oxidized products were combined as one crude. Following oxidation, the crude was subjected to DAST (40 µL, 0.303 mmol, 1.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 450 µL, .90 mmol, 3.0 eq). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 500 mL 5% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  500 mL 10% MeOH/DCM with 1% NH4OH) to afford the desired product as a pale yellow solid. To compare with the <sup>1</sup>H and <sup>13</sup>C NMR data of **S33**, we used data collected by MacMillan et  $al^{23}$ .

Run 1: 19.9 mg, 0.0725 mmol, 24% yield; 18.8 mg, 0.0722 mmol, 24% rsm

Run 2: 19.1 mg, 0.0696 mmol, 23% yield; 20.4 mg, 0.0784 mmol, 25% rsm

#### Average overall yield: 24% yield (24% rsm) $\pm 0.7$

Lower mass balance likely resulted from aromatic oxidation.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*):

δ 7.29 (t, *J* = 7.5 Hz, 2H), 7.32-7.17 (m, 3H), 5.42 (s, 1H), 3.61 (q, *J* = 6.5 Hz, 1H), 2.89-2.76 (m, 4H), 2.68-2.60 (m, 2H), 2.54-2.44 (m, 2H), 1.97-1.87 (m, 2H), 1.86-1.69 (m, 2H), 1.19 (d, *J* = 6.5 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 158.07, 140.27, 128.92, 128.68, 126.36, 82.66, 60.53, 56.72, 49.55, 49.37, 36.14, 33.92, 30.71, 16.35.

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>23</sub>N<sub>2</sub>O<sub>2</sub> [M+H]<sup>+</sup>: 275.1760, found 275.1756.



2-methyl-3-(((2S,5R)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methoxy)pyridine [32] According to a modified general oxidation procedure and the BF<sub>3</sub>-promoted methylation procedure, in a 40-mL vial was added (S)-2-methyl-3-((1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methoxy)pyridine S34 (75.5 mg, 0.20 mmol, 1.0 equiv.), CH<sub>2</sub>Cl<sub>2</sub> (0.8 mL), and HBF<sub>4</sub>•OEt<sub>2</sub> (29.9 µL, 0.22 mmol, 1.1 equiv.). The reaction mixture was stirred for 1 h, and the solvent was removed in vacuo. The crude was placed on high vacuum overnight to remove the residual acid. The crude was then redissolved in MeCN (0.4 mL, 0.5 M) and oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (27.1 mg, 0.020 mmol, 0.10 equiv.), AcOH (172  $\mu$ L, 3.00 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (56.8 µL, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M). Following oxidation, the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and poured into a 60-mL separatory funnel containing 1.5 M K<sub>2</sub>CO<sub>3</sub> (5 mL), and the mixture was shaken vigorously for deprotonation. The layers were seperated and the aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over MgSO4, and condensed in vacuo. For facile isolation, the oxidaion products were isolated by flash chromatography (50 ml silica dry loading, 200 mL  $2\% \rightarrow 5\%$ MeOH/CH<sub>2</sub>Cl<sub>2</sub>), and then methylated with trimethylaluminum (2.0 M in hexanes, 300 µL, 0.60 mmol, 3.0 equiv.) and BF<sub>3</sub>•OEt<sub>2</sub> (74.1 µL, 85.2 mg, 0.60 mmol, 3.0 equiv.). Following workup, the crude material was purified by medium-pressure liquid chromatography (12 g silica, 50 column volumes  $0\% \rightarrow 5\%$ 

MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to afford the product as a white solid as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds **13** and **42**.

**Run 1** (28.2 mg, 0.0720 mmol, 36% yield; 6:1 dr; 2% rsm by <sup>1</sup>H NMR)

**Run 2** (26.6 mg, 0.0680 mmol, 34% yield, 5:1 dr; 2% rsm by <sup>1</sup>H NMR)

**Run 3** (25.9 mg, 0.0662 mmol, 33% yield, 6:1 dr; 2% rsm by <sup>1</sup>H NMR)

# Average overall yield: 34% (2% rsm) ± 1.5, 6:1 dr

Lower mass balance was likely caused by overoxidation resulting from high catalyst loading (ca. 51% hemiaminal produced from oxidation with the rest of the material being a complex mixture).

Methylation with DAST: 28% yield, 3:1 dr by <sup>1</sup>H NMR.

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.38 (d, J = 8.7 Hz, 0.32H), 8.15 (d, J = 8.9 Hz, 1.68H), 8.11 (d, J = 4.5 Hz, 0.16H), 8.09-8.02 (m, 1.16H), 7.96 (d, J = 8.8 Hz, 1.68H), 7.18 (d, J = 8.0 Hz, 0.16H), 7.12 (dd, J = 8.2, 4.8 Hz, 0.16H), 7.05 (dd, J = 8.1, 4.8 Hz, 0.84H), 6.95 (d, J = 8.1 Hz, 0.84H), 4.33-4.18 (m, 1.84H), 4.13 (dd, J = 9.8, 2.6 Hz, 0.84H), 4.05 (dd, J = 9.8, 6.0 Hz, 0.84H), 4.02-3.93 (m, 0.32H), 3.72 (sxt, J = 6.3 Hz, 0.16H), 2.46 (s, 0.48H), 2.41-2.31 (m, 0.84H), 2.29 (s, 2.52H), 2.28-2.20 (m, 0.84H), 2.11 (dd, J = 12.9, 7.1 Hz, 0.84H), 2.08-1.99 (m, 0.16H), 1.80-1.71 (m, 0.48H), 1.65 (dd, J = 12.1, 6.8 Hz, 0.84H), 1.42 (d, J = 6.3 Hz, 0.48H), 1.29 (d, J = 6.4 Hz, 2.52H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 152.69, 152.26, 150.35, 149.64, 148.77, 148.32, 147.70, 143.35, 141.16, 141.11, 128.83, 127.91, 124.57, 124.22, 121.93, 121.78, 117.55, 116.83, 70.15, 68.34, 60.45, 59.21, 58.43, 58.03, 32.26, 31.95, 27.58, 27.51, 22.94, 21.67, 19.82, 19.72

# HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>22</sub>N<sub>3</sub>O<sub>5</sub>S [M+H]<sup>+</sup>: 392.1280, found 392.1272.



*tert*-butyl (2*R*,5*S*)-2-methyl-5-(((2-methylpyridin-3-yl)oxy)methyl)pyrrolidine-1-carboxylate [33] According to literature<sup>5</sup>, in a 25-mL recovery flask was added 2-methyl-3-(((2S,5*R*)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methoxy)pyridine **32** as a mixture of diastereomers (15.8 mg, 0.0404 mmol, 1.0 equiv.), MeCN (1.5 mL), and cesium carbonate (52.7 mg, 0.162 mmol, 4.0 equiv.). The flask was backfilled with nitrogen 3x, and DMSO (30 µL) and thiophenol (14.5 µL, 15.6 mg, 0.141 mmol, 3.5 equiv.) were added. The flask was placed in 45 °C oil bath and stirred vigorously overnight. Upon

completion, the crude was partitioned between  $CH_2Cl_2$  and sat. NaHCO<sub>3</sub> (5 mL each), and the aqueous layer was extracted with  $CH_2Cl_2$  (2x5 mL). The organic layers were combined, dried over  $K_2CO_3$ , condensed in vacuo, and purified through flask chromatography (20 mL alumina Brockman III, 150 mL 25% EtOAc/Hex $\rightarrow$ 100 mL 5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to generate the free amine as a mixture with some side products. The product was redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1 mL), and Boc<sub>2</sub>O (9.7 mg, 0.0444 mmol, 1.1 equiv.) was added. The reaction was stirred overnight, and directly purified through medium-pressure liquid chromatography (12 g silica, 50 column volumes 0% $\rightarrow$ 5% MeOH/CH<sub>2</sub>Cl<sub>2</sub>) to afford the product as a colorless oil as a mixture of diastereomers and rotamers (7.0 mg, 0.023 mmol, 57% yield, 5:1 dr).

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.13-8.02 (br s, 1H), 7.25-7.10 (m, 1H), 7.10-7.03 (m, 1H), 4.26-3.74 (m, 4H), 2.49 (s, 0.5H), 2.47 (s, 2.5H), 2.28-1.95 (m, 3H), 1.61-1.53 (m, 1H), 1.47 (s, 9H), 1.25 (d, *J* = 6.3 Hz, 0.5H), 1.23-1.15 (br s, 2.5H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 154.39, 153.66, 153.25, 153.14, 149.11, 148.76, 140.76, 140.41, 121.96, 121.73, 117.81, 117.49, 79.85, 79.59, 68.09, 67.23, 56.01, 55.98, 53.85, 53.77, 30.85, 29.76, 28.75, 28.69, 26.50, 25.66, 20.48, 19.85, 19.70, 19.52

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>27</sub>N<sub>2</sub>O<sub>3</sub> [M+H]<sup>+</sup>: 307.2022, found 307.2022.



## rel-(1R,4R)-4-(3,4-dichlorophenyl)-7-methoxy-1-methyl-2-(phenylsulfonyl)-1,2,3,4-

**tetrahydroisoquinoline** [(±)-34] Following the general oxidation and BF<sub>3</sub>-promoted procedures, phenylsulfonyl-diclofensine S35 (135.4 mg, 0.302 mmol, 1.00 eq) in 4:1 MeCN/DCM (1 mL, 0.3 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (8.2 mg, 0.0060 mmol, 0.02 eq), acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 eq), and H<sub>2</sub>O<sub>2</sub> (26  $\mu$ L, 0.604 mmol, 2 eq, 50 wt.% in H<sub>2</sub>O) in 4:1 MeCN/DCM (3.5 mL, 0.4 M) at -36 °C via single addition protocol. After 30 min, another 8.2 mg of the catalyst in 0.4 mL MeCN was added to the reaction. Following oxidation, the crude was methylated with BF<sub>3</sub> (75  $\mu$ L, 0.60 mmol, 2.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 eq). Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 30 CV 0% to 12.5%, 5 CV 12.5%, 10 CV 12.5% to 30% EtOAc/Hex) to produce the desired compound as a white powder. **Run 1:** 34.9 mg, 0.0755 mmol, 25% yield, >20:1 dr; 22% rsm by <sup>1</sup>H NMR **Run 2:** 32.1 mg, 0.0695 mmol, 23% yield, >20:1 dr; 22% rsm by <sup>1</sup>H NMR

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**Run 3:** 30.7 mg, 0.0664 mmol, 22% yield, >20:1 dr; 27% rsm by <sup>1</sup>H NMR

### Average overall yield: 23% yield (24% rsm) ± 1.2

Lower mass balance is likely a result of aromatic oxidation.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.51 (d, *J* = 7.9 Hz, 2H), 7.46 (t, *J* = 7.5 Hz, 1H), 7.31 – 7.21 (m, 2H), 7.07 (d, *J* = 8.2 Hz, 1H), 6.83 (d, *J* = 8.5 Hz, 1H), 6.76 (dd, *J* = 8.5, 2.6 Hz, 1H), 6.72 (s, 2H), 6.61 (dd, *J* = 8.3, 2.1 Hz, 1H), 5.23 (q, *J* = 6.7 Hz, 1H), 4.03 (dd, *J* = 4.0, 1.9 Hz, 1H), 3.84 (s, 3H), 3.79 (dd, *J* = 13.4, 3.8 Hz, 1H), 3.71 (dd, *J* = 13.3, 2.0 Hz, 1H), 1.60 (d, *J* = 6.7 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 158.79, 144.42, 139.94, 139.74, 132.34, 132.18, 131.37, 130.66, 130.34, 130.12, 128.76, 127.78, 127.09, 125.24, 113.95, 111.71, 55.48, 52.59, 45.39, 42.95, 22.45.

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>23</sub>H<sub>22</sub>Cl<sub>2</sub>NO<sub>3</sub>S [M+H]<sup>+</sup>: 462.0697, found 462.0680.



For NOESY see Supporting Information: Spectral Data



*rel-*(1*R*,4*R*)-4-(3,4-dichlorophenyl)-7-methoxy-1,2-dimethyl-1,2,3,4-tetrahydroisoquinoline [35] *rel-*(1*R*,4*R*)-4-(3,4-dichlorophenyl)-7-methoxy-1-methyl-2-(phenylsulfonyl)-1,2,3,4-tetrahydroisoquinoline **34** (46.2 mg, 0.1 mmol, 1 eq), magnesium turnings (243.1 mg, 10 mmol, 100 eq), and NH<sub>4</sub>Cl (534.9 mg, 10 mmol, 100 eq) were dissolved in methanol (5.3 mL). The reaction was sonicated at rt for 1 hour. The solution was passed through a celite plug, rinsed with DCM, and diluted with NaHCO<sub>3</sub>. The aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>3</sub>), concentrated *in vacuo*, and the resulting oil was dissolved in DCM (2 mL). Formaldehyde (37%, 180µL, 2.2 mmol, 22 eq) and formic acid (190 µL, 5.0 mmol, 50 eq) was added and the solution was stirred at 90 °C for 12 hours. The solution was then transferred to a separatory funnel with 10 mL 1M NaOH, and the aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>3</sub>)

and concentrated *in vacuo*. The resulting oil was purified via column chromatography (30 mL silica, DCM loaded, 100 mL  $0\% \rightarrow 5\%$  MeOH/DCM with 1% NH<sub>4</sub>OH) and furnished the desired product in 82% yield (27.6 mg, 0.82 mmol) as a transparent oil.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.34 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.27-7.25 (m, 1H), 7.01 (dd, *J* = 8.3, 1.9 Hz, 1H), 6.72 (d, *J* = 2.5 Hz, 1H), 6.70 (d, *J* = 8.6 Hz, 1H), 6.65 (dd, *J* = 8.6, 2.4 Hz, 1H), 4.16 (dd, *J* = 8.6, 5.1 Hz, 1H), 3.79 (s, 3H), 3.77 – 3.70 (m, 1H), 3.13 (dd, *J* = 11.7, 5.0 Hz, 1H), 2.59 (dd, *J* = 11.7, 8.7 Hz, 1H), 2.46 (s, 3H), 1.45 (d, *J* = 6.5 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 158.24, 145.32, 132.42, 130.88, 130.56, 130.41, 130.33, 130.11, 128.70, 128.50, 112.19, 111.85, 59.76, 59.08, 55.39, 29.85, 18.85.

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>20</sub>Cl<sub>2</sub>NO [M+H<sub>3</sub>O<sup>+</sup>]: 336.0922, found 336.0925.



For NOESY see Supporting Information: Spectral Data



**1-(3-(dimethylamino)propyl)-1-(4-fluorophenyl)-3-methyl-1,3-dihydroisobenzofuran-5-carbonitrile [36]** Following the general oxidation and DAST-promoted procedures, citalopram **S36** (98.0 mg, 0.302 mmol, 1.00 eq) was dissolved in DCM under N<sub>2</sub>. HBF<sub>4</sub>•OEt<sub>2</sub> (46  $\mu$ L, 0.332 mmol, 1.1 eq) was added and the solution was stirred for 1 h at RT before being concentrated *in vacuo*. The resulting white solid was dissolved in MeCN (1 mL, 0.3 M). Acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 eq) was added. In a 1 mL syringe, (*S,S*)-Mn(CF<sub>3</sub>PDP) (40.7 mg, 0.0303 mmol, 0.1 eq) was dissolved in MeCN (0.4 mL). In a 12 mL syringe, H<sub>2</sub>O<sub>2</sub> (34  $\mu$ L, 0.604 mmol, 2 eq, 50 wt.% in H<sub>2</sub>O) was dissolved in MeCN (3.5 mL, 0.4 M). Both syringe contents were added over the course of 1 hr using a syringe pump at -36 °C. After NaOH workup to remove the HBF<sub>4</sub> salt, the resulting oil was purified by flash chromatography (50 mL Brockman grade III Al<sub>2</sub>O<sub>3</sub>, loaded with DCM, gradient elution 200 mL 90% EtOAc/hex  $\rightarrow$  200 mL 2% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  5%  $\rightarrow$  10% MeOH/DCM with 1% NH<sub>4</sub>OH) to afford the oxidized products as a pale yellow foam. The mixture was subjected to DAST (40 µL, 0.303 mmol, 1.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 450 µL, .90 mmol, 3.0 eq). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL 50%  $\rightarrow$  70% EtOAc/Hex  $\rightarrow$  5% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  7% MeOH/DCM with 1% NH<sub>4</sub>OH  $\rightarrow$  10% MeOH/DCM with 1% NH<sub>4</sub>OH) to afford the desired product as a pale yellow oil.

**Run 1:** 38.1 mg, 0.113 mmol, 37% yield, 1:1 dr; 12% rsm by <sup>1</sup>H NMR

**Run 2:** 36.9 mg, 0.109 mmol, 36% yield, 1:1 dr; 9% rsm by <sup>1</sup>H NMR

**Run 3:** 35.8 mg, 0.106 mmol, 34% yield, 1:1 dr; 14% rsm by <sup>1</sup>H NMR

#### Average overall yield: 36% yield (12% rsm) $\pm 1.5$

Lower mass balance is likely the result of aromatic (fluorinated phenyl) oxidation caused by the high catalyst loading.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.58 – 7.51 (m, 0.9H), 7.50 – 7.45 (m, 1H), 7.46 – 7.41 (m, 2.1H), 7.40 – 7.29 (m, 4.4H), 7.23 – 7.13 (m, 1H), 6.97 – 6.90 (m, 3.8H), 5.39 (q, *J* = 6.4 Hz, 1H), 5.20 (q, *J* = 6.3 Hz, 0.9H), 2.27 – 1.98 (m, 18.3H), 1.52 (app t, *J* = 6.4 Hz, 5.5H), 1.41 (m, 2.2H), 1.31 – 1.20 (m, 2.5H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-d)

δ 162.09 (d, *J* = 246.2 Hz), 162.04 (d, *J* = 246.1 Hz), 149.85, 149.45, 144.88, 144.20, 140.40 (d, *J* = 3.3 Hz), 139.88 (d, *J* = 3.2 Hz), 132.04, 132.00, 127.14 (d, *J* = 8.1 Hz), 126.78 (d, *J* = 7.9 Hz), 125.27, 125.25, 123.02, 122.81, 118.78, 118.76, 115.33 (d, *J* = 21.4 Hz), 115.32 (d, *J* = 21.6 Hz), 111.91, 111.88, 90.43, 90.12, 78.67, 77.31, 59.47, 59.45, 45.35, 39.56, 39.12, 22.36, 22.26, 21.15.

<sup>19</sup>F NMR: (471 MHz, Chloroform-*d*)

 $\delta$  -114.53 (dtd, J = 17.2, 8.7, 4.4 Hz), -115.59 (dtd, J = 17.6, 8.4, 4.2 Hz). HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>21</sub>H<sub>24</sub>FN<sub>2</sub>O [M+H]<sup>+</sup>: 339.1873, found 339.1866.



*rel-(6R*,10b*R*)-9-chloro-6-(4-chlorophenyl)-3-methyl-2,3,6,10b-tetrahydropyrrolo[2,1-*a*]isoquinolin-5(1*H*)-one [(±)-37] According to the general oxidation and DAST-promoted methylation procedures, *rel-* (6*R*,10b*R*)-9-chloro-6-(4-chlorophenyl)-2,3,6,10b-tetrahydropyrrolo[2,1-*a*]isoquinolin-5(1*H*)-one (±)-S37 (33.2 mg, 0.10 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.17 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.7 mg, 0.002 mmol, 0.02 equiv.), AcOH (86  $\mu$ L, 1.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (28.4  $\mu$ L, 0.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (1.25 mL, 0.4 M), and methylated with DAST (13.2  $\mu$ L, 16.1 mg, 0.10 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 150  $\mu$ L, 0.30 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, 200 mL 20%-30%-50% EtOAc/Hex) to afford the product as a colorless oil as a mixture of diastereomers.

Run 1 (14.1 mg, 0.0407 mmol, 41% yield, 4:1 dr; 11.4 mg, 0.0343 mmol, 34% rsm)

**Run 2** (14.2 mg, 0.0410 mmol, 41% yield, 4:1 dr; 14.5 mg, 0.0436 mmol, 44% rsm)

**Run 3** (16.8 mg, 0.0485 mmol, 49% yield, 4:1 dr; 12.2 mg, 0.0367 mmol, 37% rsm)

Average overall yield: 44% (38% rsm) ± 4.6, 4:1 dr

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.36 (d, J = 8.0 Hz, 0.8H), 7.32 (d, J = 8.0 Hz, 0.2H), 7.28-7.26 (m, 0.8H), 7.26-7.24 (m, 0.2H), 7.24-7.20 (m, 2H), 7.19 (d, J = 8.2 Hz, 0.8H), 7.15 (d, J = 8.0 Hz, 0.2H), 7.03 (d, J = 8.6 Hz, 2H), 4.84 (s, 0.8H), 4.76 (s, 0.2H), 4.53 (dd, J = 10.7, 5.9 Hz, 0.2H), 4.38 (dd, J = 11.0, 5.9 Hz, 0.8H), 4.26-4.14 (m, 1H), 2.53 (dd, J = 12.2, 6.2 Hz, 0.2H), 2.48-2.38 (m, 0.8H), 2.30 (dt, J = 13.7, 7.3 Hz, 0.2H), 2.18-2.03 (m, 1.6H), 1.89-1.71 (m, 1H), 1.63-1.54 (m, 0.2H), 1.31 (d, J = 6.2 Hz, 0.6H), 1.23 (d, J = 6.3 Hz, 2.4H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 168.02, 167.54, 139.75, 138.45, 136.98, 135.13, 134.70, 133.65, 133.55, 133.40, 133.28, 129.33, 129.89, 128.98, 128.91, 128.77, 128.57, 128.45, 125.21, 124.43, 59.13, 58.70, 53.95, 53.77, 53.40, 53.21, 32.01, 31.62, 31.14, 28.28, 19.99, 19.62

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>19</sub>H<sub>18</sub>NOCl<sub>2</sub> [M+H]<sup>+</sup>: 346.0765, found 346.0751.



((4*S*,5*R*)-3-(4-bromo-3-fluorophenyl)-4-methyl-2-oxooxazolidin-5-yl)methyl acetate [38] According to the general oxidation and TFAA-promoted methylation procedures, (*R*)-(3-(4-bromo-3-fluorophenyl)-2-oxooxazolidin-5-yl)methyl acetate **S38** (99.6 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (8.1 mg, 0.0060 mmol, 0.02 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (85.2  $\mu$ L, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M).

Following oxidation, the crude was methylated with TFAA (41.7  $\mu$ L, 63.0 mg, 0.30 mmol, 1.0 equiv.), trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.), and TMSOTf (54.5  $\mu$ L, 66.7 mg, 0.30 mmol, 1.0 equiv.). Following workup, the crude material was purified by medium-pressure liquid chromatography (12 g silica, 50 column volumes 0% $\rightarrow$ 50% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers. The stereochemistry was determined by <sup>1</sup>H NMR and NOESY 1D methods.

Run 1 (46.8 mg, 0.135 mmol, 45% yield; 6:1 dr; 38.9 mg, 0.117 mmol, 39% rsm) Run 2 (45.0 mg, 0.130 mmol, 43% yield, 7:1 dr; 36.9 mg, 0.111 mmol, 37% rsm) Run 3 (46.0 mg, 0.133 mmol, 44% yield, 5:1 dr; 33.1 mg, 0.100 mmol, 33% rsm) Average overall yield: 44% (36% rsm) ± 1.0, 6:1 dr

Methylation with DAST:

**Run 1** (31.7 mg, 0.0916 mmol, 31% yield, 11:1 dr; 7.6 mg, 0.020 mmol, 6% hemiaminal acetate; 41.1 mg, 0.124 mmol, 41% rsm)

**Run 2** (32.2 mg, 0.0930 mmol, 31% yield, 12:1 dr; 10.0 mg, 0.0256 mmol, 9% hemiaminal acetate; 42.5 mg, 0.128 mmol, 43% rsm)

Average overall yield: 31% (42% rsm) ± 0.0, 12:1 dr; 8% hemiaminal acetate

Gram scale: Following the general oxidation and TFAA-promoted procedures, (*R*)-(3-(4-bromo-3-fluorophenyl)-2-oxooxazolidin-5-yl)methyl acetate (1.00 g, 3.02 mmol, 1.0 equiv.) in MeCN (7 mL) in a 100 mL round-bottom flask was oxidized with (S,S)-Mn(CF<sub>3</sub>PDP) (81.6 mg, 0.0604 mmol, 0.02 equiv.), acetic acid (2.59 mL, 45.3 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (855  $\mu$ L, 15.1 mmol, 5.0 equiv., 50 wt.% in H<sub>2</sub>O) in MeCN (37.5 mL, in 50 mL HSW syringe). Following oxidation, the solution was passed through 100 mL silica and flushed with 1 L of EtOAc. The solution was concentrated *in vacuo* and transferred to a 100 mL round bottom flask and left on a high vacuum pump overnight. The crude was then dissolved in 40 mL of CH<sub>2</sub>Cl<sub>2</sub> under nitrogen. TFAA (418  $\mu$ L, 3.02 mmol, 1.0 equiv.) was added and the solution was stirred for an hour. Subsequently, the solution was cooled to -78°C and AlMe<sub>3</sub> (4.52 mL, 9.06 mmol, 3.0 equiv.) was added dropwise along the side of the flask. TMSOTf (545  $\mu$ L, 3.02 mmol, 1 eq) was then added dropwise, and the reaction was stirred at -78°C for an hour before removing the dry ice bath and stirring at rt for 3 hours. A 3 M solution of sodium hydroxide (100 mL) was cooled to 0 °C at the end of the reaction and transferred to a 250 mL separatory funnel. The reaction mixture was cooled to 0 °C and slowly transferred to the separatory funnel. The organic layer was carefully extracted, and the aqueous layer was washed with EtOAc (3 x 30 mL). The combined organic layers were dried with Na<sub>2</sub>SO<sub>4</sub>,

concentrated *in vacuo*, and purified via MPLC (40 g silica, 60 column volumes  $0\% \rightarrow 30\%$  EtOAC/Hex) to afford the desired product as a white solid as a mixture of diastereomers.

Run 1 (463 mg, 1.34 mmol, 44% yield, 4:1 dr; 369.7 mg, 1.11 mmol, 37% rsm)

**Run 2** (482 mg, 1.39 mmol, 46% yield, 4:1 dr; 358.1 mg, 1.08 mmol, 36% rsm)

## Average overall yield: 45% (37% rsm), 4:1 dr

Characterization of major diastereomer 38:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.54 (d, *J* = 8.2 Hz, 1H), 7.38 (dd, *J* = 10.4, 2.5 Hz, 1H), 7.09 (dd, *J* = 8.8, 2.5 Hz, 1H), 4.39 (q, *J* = 4.7 Hz, 1H), 4.36-4.27 (m, 2H), 4.24 (p, *J* = 6.0 Hz, 1H), 2.08 (s, 3H), 1.40 (d, *J* = 6.2 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.62, 159.37 (d, *J* = 247.1 Hz), 154.01, 137.30 (d, *J* = 9.3 Hz), 133.78 (d, *J* = 1.5 Hz), 117.43 (d, *J* = 3.4 Hz), 109.71 (d, *J* = 26.8 Hz), 104.67 (d, *J* = 21.1 Hz), 77.64, 63.57, 54.19, 20.74, 18.60

<sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

 $\delta$  -104.50 (dd, J = 10.3, 7.8 Hz)

#### HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>13</sub>H<sub>14</sub>NO<sub>4</sub>FBr [M+H]<sup>+</sup>: 346.0090, found 346.0088.

 $[\alpha]_{D}^{24} = -44.3^{\circ} (c = 1.10, CH_2Cl_2)$ 



For NOESY see Supporting Information: Spectral Data



((3*S*,4*R*,6*R*)-4-(4-fluorophenyl)-6-methyl-1-((4-nitrophenyl)sulfonyl)piperidin-3-yl)methyl acetate [39] Following the general oxidation and BF<sub>3</sub>-promoted methylation procedures, ((3*S*,4*R*)-4-(4-fluorophenyl)-1-((4-nitrophenyl)sulfonyl)piperidin-3-yl)methyl acetate **S39** (131.8 mg, 0.302 mmol, 1 eq) and acetic acid (259  $\mu$ L, 4.53 mmol, 15.0 eq) were dissolved in MeCN (0.6 mL, 0.4 M). (*R*,*R*)-Mn(CF<sub>3</sub>PDP) (40.9 mg, 0.03 mmol, 0.1 eq) was dissolved in MeCN (0.4 mL), and H<sub>2</sub>O<sub>2</sub> (86  $\mu$ L, 1.51 mmol, 5 eq, 50 wt.% in H<sub>2</sub>O) was dissolved in MeCN (3 mL) in separate syringes. The two separate solutions of catalyst and oxidant were added over 1 hour using a syringe pump at 0 °C. Following oxidation, the crude was methylated with BF<sub>3</sub> (75  $\mu$ L, .60 mmol, 2.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 450  $\mu$ L, .90 mmol, 3.0 eq). Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 25 CV 0% to 15%, 3 CV 15%, 4 CV 15% to 17.5%, 5 CV 17.5% EtOAc/Hex) to produce the desired compound as a mixture with RSM.

**Run 1:** 47.6 mg, 0.106 mmol, 35% yield > 20:1 dr; 16% rsm by  $^{1}$ H NMR.

**Run 2:** 44.9 mg, 0.100 mmol, 33% yield > 20:1 dr; 14% rsm by  ${}^{1}$ H NMR.

**Run 3:** 46.3 mg, 0.103 mmol, 34% yield > 20:1 dr; 20% rsm by  ${}^{1}$ H NMR.

## Average overall yield: 34% yield (16% rsm) ± 0.8

The desired methylated product was cleanly isolated when the oxidation product was cleanly isolated. After oxidation (see above), the crude material was purified by column chromatography (50 mL silica, loaded with DCM and ethyl acetate, gradient elution 200 mL  $0\% \rightarrow 10\% \rightarrow 600$  mL  $20\% \rightarrow 100\%$  ethyl acetate/hexane). All oxidized products were collected and submitted to the methylation conditions mentioned above. Following workup, the crude material was purified by column chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL  $0\% \rightarrow 5\% \rightarrow 10\% \rightarrow 15\% \rightarrow 20\% \rightarrow 25\%$  ethyl acetate/hexane) to produce the desired compound as a white solid in 28% yield.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 8.39 (d, *J* = 8.7 Hz, 2H), 8.04 (d, *J* = 8.8 Hz, 2H), 7.04 (dd, *J* = 8.6, 5.5 Hz, 2H), 6.98 (t, *J* = 8.6 Hz, 2H), 4.42 (p, *J* = 6.3 Hz, 1H), 4.03 (dd, *J* = 13.4, 4.4 Hz, 1H), 3.82 (dd, *J* = 11.6, 3.4 Hz, 1H), 3.64 (dd, *J* = 11.6, 7.7 Hz, 1H), 2.93 (dd, *J* = 13.5, 11.5 Hz, 1H), 2.69 (td, *J* = 12.4, 3.7 Hz, 1H), 2.08-2.03 (m, 1H), 2.02 (s, 3H), 1.89 (td, *J* = 13.3, 5.3 Hz, 1H), 1.66 (ddd, *J* = 13.6, 3.8, 1.9 Hz, 1H), 1.12 (d, *J* = 6.9 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 170.79, 161.96 (d, *J* = 245.7 Hz), 150.10, 147.00, 137.67 (d, *J* = 3.3 Hz), 128.77 (d, *J* = 7.9 Hz), 128.28, 124.66, 115.98 (d, *J* = 21.3 Hz), 64.31, 49.05, 42.94, 41.29, 39.40, 38.25, 20.91, 15.61. <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>21</sub>H<sub>24</sub>FN<sub>2</sub>O<sub>6</sub>S [M+H]<sup>+</sup>: 451.1339, found 451.1332.

 $[\alpha]_{D}^{24} = -27.0 \text{ (c} = 1.00, \text{ EtOH)}$ 



For COSY see Supporting Information: Spectral Data



*tert*-butyl (2*R*,4*R*,5*S*)-5-(acetoxymethyl)-4-(4-fluorophenyl)-2-methylpiperidine-1-carboxylate [40] ((3*S*,4*R*,6*R*)-4-(4-fluorophenyl)-6-methyl-1-((4-nitrophenyl)sulfonyl)piperidin-3-yl)methyl acetate **39** (65.0 mg, 0.144 mmol, 1 eq) was dissolved in a 45:1 MeCN/DMSO solution (0.1 M). Thiophenol (52  $\mu$ L, 0.504 mmol, 3.5 eq) and Cs<sub>2</sub>CO<sub>3</sub> (187.2 mg, 0.58 mmol, 4 eq) were subsequently added. The reaction was stirred at 45°C overnight. The reaction was then diluted with brine (10 mL) and DCM (15 mL), and the aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>3</sub>), concentrated *in vacuo*, and the resulting oil was then dissolved in DCM (5 mL). Boc<sub>2</sub>O (157 mg, 0.792 mmol, 5 eq) was added and the reaction as stirred at rt overnight before being diluted with NaHCO<sub>3</sub> (15 mL). The aqueous layer was extracted with DCM (3 x 10 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>3</sub>), concentrated *in vacuo*, and the resulting oil was purified by column chromatography (20 mL silica, DCM loaded, 200 mL 0%  $\rightarrow$  10  $\rightarrow$  20% EtOAC/hex) to afford the desired product as an oil in 86% yield as a mixture of rotamers (45.2 mg, 0.124 mmol).

# <sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.16 – 7.07 (m, 2H), 6.99 (t, *J* = 8.6 Hz, 2H), 4.66 – 4.35 (m, 1H), 4.35 – 3.99 (m, 1H), 3.87-3.77 (m, 1H), 3.67 (dd, *J* = 11.3, 8.1 Hz, 1H), 2.87 – 2.51 (m, 2H), 2.02 – 1.91 (m, 4H), 1.87 (td, *J* = 13.2, 5.6 Hz, 1H), 1.70 – 1.59 (m, 1H), 1.48 (s, 9H), 1.21 (d, *J* = 6.9 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 171.03, 170.90, 161.77 (d, *J* = 244.9 Hz), 155.08, 154.60, 138.88 (d, *J* = 3.1 Hz), 128.82 (d, *J* = 7.8 Hz), 115.72 (d, *J* = 21.2 Hz), 79.81, 65.05, 64.85, 46.85, 45.65, 41.91, 41.49, 41.02, 40.94, 39.32, 39.02, 29.83, 28.60, 20.87, 16.16, 15.91.

<sup>19</sup>F NMR: (471 MHz, Chloroform-*d*)

δ -116.08 (m).

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>20</sub>H<sub>29</sub>FNO<sub>4</sub> [M+H<sup>+</sup>]: 366.2081, found 366.2078.

 $[\alpha]_D^{19} = -63.3^\circ (c = 1.00, EtOH)$ 



**2-methyl-1-((4-(5-(***p***-tolyl)-3-(trifluoromethyl)-1***H***-pyrazol-1-yl)phenyl)sulfonyl)piperidine [41] Following the general oxidation and BF<sub>3</sub>-promoted procedures, 1-((4-(5-(***p***-tolyl)-3-(trifluoromethyl)-1***H***pyrazol-1-yl)phenyl)sulfonyl)piperidine <b>S40** (271.5 mg, 0.604 mmol, 1.00 eq) in MeCN/DCM (2:0.5 mL) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (4.1 mg, 0.003 mmol, 0.005 eq), acetic acid (518 µL, 9.06 mmol, 15.0 eq), and H<sub>2</sub>O<sub>2</sub> (172 µL, 3.0 mmol, 5 eq, 50 wt.% in H<sub>2</sub>O) in MeCN/DCM (5.6 mL:1.4 mL), at 0 °C via single addition protocol. Following workup, the crude material was purified to separate the starting material from all oxidized products via column chromatography (50 mL silica, DCM loaded, 150 mL 0%  $\rightarrow$  300 mL 10%  $\rightarrow$  20%  $\rightarrow$  100% ethyl acetate/hexane). The starting material was isolated and resubmitted to the oxidation. The combined oxidation products were submitted to the methylation with BF<sub>3</sub> (150 µL, 1.2 mmol, 2.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 900 µL, 1.8 mmol, 3.0 eq). Following workup, the crude material was purified by MPLC (40 g silica, dry loaded, gradient elution 30 CV 0% to 5%, 15 CV 5% EtOAc/Hex) to produce the desired compound as a white powder.

**Run 1:** 114.9 mg, 0.248 mmol, 41% yield; 20% rsm by <sup>1</sup>H NMR

**Run 2:** 109.6 mg, 0.236 mmol, 39% yield; 18% rsm by <sup>1</sup>H NMR

Average overall yield: 40% yield (19% rsm) ± 1.4

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.80 (d, *J* = 8.6 Hz, 2H), 7.44 (d, *J* = 8.5 Hz, 2H), 7.15 (d, *J* = 7.8 Hz, 2H), 7.08 (d, *J* = 8.1 Hz, 2H), 6.74 (s, 1H), 4.23 (p, *J* = 6.3 Hz, 1H), 3.71 (dt, *J* = 12.3, 3.3 Hz, 1H), 2.99 (td, *J* = 13.2, 2.6 Hz, 1H), 2.37 (s, 3H), 1.63 – 1.50 (m, 4H), 1.44 (m, 1H), 1.39 – 1.29 (m, 1H), 1.07(d, *J* = 6.93 Hz, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 145.26, 143.99 (q, *J* = 38.5 Hz), 142.01, 141.06, 139.73, 129.67, 128.70, 127.89, 125.71, 125.61, 121.08 (q, *J* = 269.2 Hz), 106.12 (d, *J* = 2.1 Hz), 48.71, 40.40, 30.30, 25.20, 21.31, 18.09, 15.49.

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<sup>19</sup>F NMR: (471 MHz, Chloroform-d)
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δ -62.40.

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>23</sub>H<sub>25</sub>F<sub>3</sub>N<sub>3</sub>O<sub>2</sub>S [M+H]<sup>+</sup>: 464.1620, found 464.1609.



Methyl ((2*S*,5*R*)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonyl)-*L*-alaninate [42] According to the general oxidation and DAST-promoted methylation procedures, methyl ((4nitrophenyl)sulfonyl)-*L*-prolyl-*L*-alaninate S41 (115.6 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (85.2  $\mu$ L, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). Following oxidation, the crude was methylated with DAST (39.6  $\mu$ L, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 20%→400 mL 30% EtOAc/Hex) to afford the product as a white solid or gel. The stereochemistry was determined based on <sup>1</sup>H NMR, COSY, and NOESY 1D NMR methods.

**Run 1** (75.7 mg, 0.189 mmol, 63% yield; 6:1 dr; 3% rsm by <sup>1</sup>H NMR)

**Run 2** (75.5 mg, 0.189 mmol, 63% yield, 6:1 dr; 2% rsm by <sup>1</sup>H NMR)

**Run 3** (73.5 mg, 0.184 mmol, 61% yield, 6:1 dr; 6% rsm by <sup>1</sup>H NMR)

# Average overall yield: 62% (4% rsm) ± 1.2, 6:1 dr

A similar yield (69.0 mg, 0.173 mmol, 58% yield; 5:1 dr; 14% rsm by <sup>1</sup>H NMR) was obtained when substituting DAST for Deoxo-Fluor (55.3  $\mu$ L, 66.4 mg, 0.30 mmol, 1.0 equiv.).

Characterization for major diastereomer 42:

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.33 (d, *J* = 8.9 Hz, 2H), 8.06 (d, *J* = 8.9 Hz, 2H), 6.38 (d, *J* = 7.2 Hz, 1H), 4.45 (p, *J* = 7.2 Hz, 1H), 4.40-4.36 (m, 1H), 4.07-4.00 (m, 1H), 3.75 (s, 3H), 2.32-2.20 (m, 2H), 2.11-2.00 (m, 1H), 1.66-1.58 (m, 1H), 1.43 (d, *J* = 7.2 Hz, 3H), 1.30 (d, *J* = 6.4 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 173.13, 170.79, 150.10, 146.04, 129.02, 124.13, 63.10, 57.21, 52.77, 48.42, 32.46, 29.09, 21.42, 18.42

## HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>16</sub>H<sub>22</sub>N<sub>3</sub>O<sub>7</sub>S [M+H]<sup>+</sup>: 400.1178, found 400.1180.

 $[\alpha]_{D}^{24} = -102.0^{\circ} (c = 0.10, CH_2Cl_2)$ 



For COSY and NOESY see Supporting Information: Spectral Data



methyl ((2*S*,*SR*)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonyl)-*L*-leucyl-*L*-alaninate [43] According to the general oxidation and DAST-promoted methylation procedures, methyl ((4nitrophenyl)sulfonyl)-*L*-prolyl-*L*-leucyl-*L*-alaninate **S42** (149.6 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257 µL, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (85.2 µL, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). For facile product isolation, the oxidized products were isolated following oxidation by flash chromatography (dry loading, 50 mL silica, gradient elution 200 mL 20% $\rightarrow$ 30% $\rightarrow$ 40% $\rightarrow$ 100% EtOAc/CHCl<sub>3</sub>). The starting material was resubjected 1x to the oxidation conditions, and the oxidized products were combined. The combined hemiaminal was then methylated with DAST (39.6 µL, 48.3 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 500 mL 50% $\rightarrow$ 200 mL 75% EtOAc/Hex) to afford the product as a white solid as a mixture of diastereomers. The stereochemistry was determined by analogy to compounds **13** and **42**.

**Run 1** (93.4 mg, 0.182 mmol, 61% yield, 6:1 dr; 31.3 mg, 0.0628 mmol, 21% rsm)

**Run 2** (86.8 mg, 0.169 mmol, 56% yield, 8:1 dr; 33.9 mg, 0.0680 mmol, 23% rsm)

## Average overall yield: 59% (22% rsm) ± 3.5, 7:1 dr

Methylation with BF<sub>3</sub>•OEt<sub>2</sub>: trace yield, 18% rsm by <sup>1</sup>H NMR.

Characterization for major diastereomer 43:

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.36 (d, *J* = 8.8 Hz, 2H), 8.11 (d, *J* = 8.9 Hz, 2H), 6.85 (d, *J* = 7.7 Hz, 1H), 6.43 (d, *J* = 8.5 Hz, 1H), 4.54 (p, *J* = 7.3 Hz, 1H), 4.47 (td, *J* = 9.4, 4.8 Hz, 1H), 4.32 (d, *J* = 8.6 Hz, 1H), 4.24 (p, *J* = 6.5 Hz, 1H), 3.73 (s, 3H), 2.26 (tdd, *J* = 12.0, 8.7, 6.1 Hz, 1H), 2.17 (dq, *J* = 12.0, 5.6, 4.8 Hz, 1H), 2.13-2.06 (m, 1H), 1.82 (ddd, *J* = 13.8, 8.8, 4.8 Hz, 1H), 1.68-1.54 (m, 3H), 1.37

(d, J = 7.3 Hz, 3H), 1.21 (d, J = 6.4 Hz, 3H), 0.97 (d, J = 6.6 Hz, 3H), 0.95 (d, J = 6.5 Hz, 3H)<u>1<sup>3</sup>C NMR:</u> (126 MHz, CDCl<sub>3</sub>)

δ 173.20, 171.25, 171.20, 150.31, 145.31, 129.19, 124.40, 62.96, 57.99, 52.55, 52.12, 48.22, 41.01, 32.18, 29.55, 25.18, 23.26, 21.74, 20.46, 18.16

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>22</sub>H<sub>33</sub>N<sub>4</sub>O<sub>8</sub>S [M+H]<sup>+</sup>: 513.2019, found 513.2025. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -101.9° (c = 0.87, CH<sub>2</sub>Cl<sub>2</sub>)



5-(*Tert*-butyl) 1-methyl ((2*S*,5*R*)-5-methyl-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carbonyl)-*L*leucyl-*L*-alanyl-*L*-glutamate [44] According to the general oxidation and fluorination-promoted methylation procedures, 5-(*tert*-butyl) 1-methyl ((4-nitrophenyl)sulfonyl)-*L*-prolyl-*L*-leucyl-*L*-alanyl-*L*glutamate **S43** (205.1 mg, 0.30 mmol, 1.0 equiv.) in MeCN (0.6 mL, 0.5 M) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 equiv.), AcOH (257  $\mu$ L, 4.50 mmol, 15.0 equiv.), and H<sub>2</sub>O<sub>2</sub> (85.2  $\mu$ L, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). For facile product isolation, the oxidized products were isolated following oxidation by flash chromatography (dry loading, 50 mL silica, gradient elution 200 mL 50% $\rightarrow$ 60% $\rightarrow$ 400 mL 70% EtOAc/Hex), and methylated with Deoxo-Fluor (55.3  $\mu$ L, 66.4 mg, 0.30 mmol, 1.0 equiv.) and trimethylaluminum (2.0 M in hexanes, 450  $\mu$ L, 0.90 mmol, 3.0 equiv.). Following workup, the crude material was purified by flash chromatography (50 mL silica, gradient elution 200 mL 20% $\rightarrow$ 400 mL 30% EtOAc/Hex) to afford the product as a white solid. The starting material was then resubjected once to the oxidation and methylation conditions. The stereochemistry was determined by analogy to compounds **13** and **42**.

**Run 1** (1<sup>st</sup> cycle: 81.3 mg, 0.117 mmol, 39% yield, 6:1 dr; 75.2 mg, 0.110 mmol, 37% rsm. 2<sup>nd</sup> cycle: 26.8 mg, 0.0384 mmol, 35% yield, 4:1 dr; 37.1 mg, 0.0543 mmol, 49% rsm. Overall: 108.1 mg, 0.155 mmol, 52% yield, 5:1 dr; 37.1 mg, 0.0543 mmol, 18% rsm)

**Run 2** (1<sup>st</sup> cycle: 71.4 mg, 0.102 mmol, 34% yield, 5:1 dr; 97.7 mg, 0.143 mmol, 48% rsm. 2<sup>nd</sup> cycle: 31.8 mg, 0.0456 mmol, 32% yield, 5:1 dr; 52.6 mg, 0.0769 mmol, 54% rsm. Overall: 103.2 mg, 0.148 mmol, 49% yield, 5:1 dr; 52.6 mg, 0.0769 mmol, 26% rsm)

**Run 3** (1<sup>st</sup> cycle: 80.6 mg, 0.115 mmol, 38% yield, 6:1 dr; 113.2 mg, 0.166 mmol, 55% rsm. 2<sup>nd</sup> cycle: 27.2 mg, 0.0390 mmol, 29% yield, 4:1 dr; 49.6 mg, 0.0725 mmol, 55% rsm. Overall: 107.8 mg, 0.154 mmol, 51% yield, 5:1 dr; 49.6 mg, 0.0725 mmol, 24% rsm)

### Average overall yield: 51% (23% rsm) ± 1.5, 5:1 dr

Characterization for major diastereomer 44:

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.41 (d, *J* = 8.3 Hz, 2H), 8.15 (d, *J* = 8.3 Hz, 2H), 7.05 (d, *J* = 7.9 Hz, 1H), 6.95 (d, *J* = 7.9 Hz, 1H), 6.43 (d, *J* = 7.5 Hz, 1H), 4.52 (app p, *J* = 7.4 Hz, 2H), 4.45-4.36 (m, 2H), 4.33 (p, *J* =

6.6 Hz, 1H), 3.74 (s, 3H), 2.42-2.23 (m, 3H), 2.21-2.07 (m, 3H), 2.07-1.96 (m, 1H), 1.91-1.80 (m, 1H), 1.73-1.59 (m, 3H), 1.45 (s, 9H), 1.35 (d, *J* = 7.1 Hz, 3H), 1.11 (d, *J* = 6.4 Hz, 3H), 1.10 (d, *J* = 6.0 Hz, 3H), 0.95 (d, *J* = 6.1 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 172.37, 172.10, 172.07, 171.43, 150.49, 145.47, 129.21, 124.70, 80.97, 63.07, 58.07, 53.02, 52.59, 51.98, 48.93, 40.52, 32.23, 31.92, 29.55, 28.25, 27.50, 25.47, 23.30, 21.51, 19.95, 17.56 <u>HRMS:</u> (ESI-TOF MS ES+)

m/z calculated for C<sub>31</sub>H<sub>48</sub>N<sub>5</sub>O<sub>11</sub>S [M+H]<sup>+</sup>: 698.3071, found 698.3071. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = -73.0° (c = 0.38, CH<sub>2</sub>Cl<sub>2</sub>)



(2*S*,3*aR*,5*aS*,9*aS*,9*bR*)-2,3*a*,6,6,9*a*-pentamethyldodeca-hydronaphtho[2,1-*b*]furan [45] Following the general oxidation and DAST-promoted methylation protocols, (–)-Ambroxide S44 (71.5 mg, 0.302 mmol, 1 eq) in 4:1 MeCN/DCM (1.25 mL) was oxidized with (*S*,*S*)-Mn(CF<sub>3</sub>PDP) (2.0 mg, 0.0015 mmol, 0.005 eq), acetic acid (259 µL, 4.53 mmol, 15 eq), and H<sub>2</sub>O<sub>2</sub> (34 µL, 0.604 mmol, 2 eq) in 4:1 MeCN/DCM (3.5 mL, 0.4 M), at -36 °C via single addition protocol. Following oxidation, the crude mixture was methylated with DAST (40 µL, 0.302 mmol, 1 eq) and AlMe<sub>3</sub> (450 µL, 0.90 mmol, 3 eq). Following workup, the resulting oil was purified using liquid chromatography (50 mL silica, loaded with DCM, 300 mL 0%  $\rightarrow$  0.5%  $\rightarrow$  1%  $\rightarrow$  1.5%  $\rightarrow$  2%  $\rightarrow$  4% EtOAc/Hex) to afford the desired products. The major was isolated, while the minor was only recovered as a mixture with the major and the rsm. The stereochemistry was assigned by matching with the <sup>1</sup>H NMR data reported in the literature<sup>24</sup>.

**Run 1:** 24.3 mg, 0.0970 mmol, 32% yield, 3:1 dr; 27% rsm by <sup>1</sup>H NMR

**Run 2:** 26.8 mg, 0.107 mmol, 35% yield, 3:1 dr; 21% rsm by <sup>1</sup>H NMR.

**Run 3:** 21.2 mg, 0.0846 mmol, 28% yield, 3:1 dr; 24% rsm by <sup>1</sup>H NMR.

Average overall yield: 32% yield (24% rsm)  $\pm 2.9$ , 3:1 dr.

19% of lactone product (sclareolide) was also isolated.

Characterization of major diastereomer 45:

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 4.21 (dqd, *J* = 8.9, 6.3, 2.7 Hz, 1H), 1.96 – 1.84 (m, 2H), 1.73 (dq, *J* = 13.9, 3.2 Hz, 1H), 1.70 – 1.59 (m, 1H), 1.51 – 1.35 (m, 5H), 1.29 (ddt, *J* = 14.4, 10.4, 3.2 Hz, 2H), 1.18-1.13 (m, 1H), 1.18 (d, *J* = 6.2 Hz, 3H), 1.11 (s, 3H), 1.06 – 0.94 (m, 2H), 0.87 (s, 3H), 0.82 (s, 6H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 81.29, 71.77, 59.13, 57.47, 42.64, 40.28, 40.07, 36.21, 33.74, 33.25, 30.02, 23.38, 21.68, 21.30, 20.73, 18.58, 15.11.

 $[\alpha]_D^{22} = -34.3 \text{ (c} = 1.00, \text{ EtOH)}$ 



Characterization of minor diastereomer S45:

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 4.08 (dp, *J* = 8.8, 6.3 Hz, 1H), 1.92 (dt, *J* = 11.4, 3.2 Hz, 1H), 1.88 – 1.79 (m, 1H), 1.73 (dq, *J* = 13.9, 3.2 Hz, 1H), 1.70 – 1.60 (m, 1H), 1.53 (dd, *J* = 13.5, 5.2 Hz, 1H), 1.48 – 1.34 (m, 4H), 1.32-1.23 (m, 2H), 1.28 (d, *J* = 6.3 Hz, 3H), 1.18 (dd, *J* = 13.8, 4.6 Hz, 1H), 1.13 (d, *J* = 0.9 Hz, 3H), 1.04 (dd, *J* = 12.9, 3.8 Hz, 1H), 0.95 (dd, *J* = 12.4, 2.8 Hz, 1H), 0.86 (s, 3H), 0.84 (s, 3H), 0.82 (s, 3H).

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 80.48, 74.58, 61.69, 57.28, 42.65, 40.69, 40.22, 36.41, 33.70, 33.27, 31.16, 25.10, 23.88, 21.24, 20.97, 18.61, 15.75.

HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>17</sub>H<sub>31</sub>O [M+H]<sup>+</sup>: 251.2375, found 251.2380.

Oxidation of S44 using 10 mol% 1 and 5 equiv. H<sub>2</sub>O<sub>2</sub>:

Run 1: 24.2 mg, 0.0966 mmol, 32% sclareolide; 1.8 mg, 0.006 mmol, 2% hemiacetal acetate.

Run 2: 26.0 mg, 0.103 mmol, 34% sclareolide; 0.9 mg, 0.003 mmol, 1% hemiacetal acetate.

Average yield: 0% hemiacetal (0% rsm); 2% hemiacetal acetate; 33% sclareolide



Characterization of hemiacetal intermediate (NOTE: exists as an equilibrium with the open form of the hemiacetal which is the aldehyde):

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 9.75 (s, 0.2H), 5.57 – 5.20 (m, 1H), 3.08-2.80 (m, 0.5 H), 2.67 – 2.27 (m, 0.2H), 2.01 – 1.87 (m, 1.8H), 1.74 – 1.59 (m, 4H), 1.47 – 1.34 (m, 4.8H), 1.34 – 1.09 (m, 7H), 1.07 – 0.90 (m, 2H), 0.89 – 0.78 (m, 12H).



Characterization of hemiacetal acetate intermediate (NOTE: not very stable to column conditions, can revert back to the hemiaminal)

<sup>1</sup><u>H NMR:</u> (400 MHz, Chloroform-*d*)

δ 6.25-6.17 (m, 1H), 2.23-2.08 (m, 1H), 2.05 (s, 3H), 2.02-1.88 (m, 1H), 1.88-1.59 (m, 3H), 1.55-1.36 (m, 4H), 1.36-1.15 (m, 2H), 1.26 (s, 3H), 1.16-0.90 (m, 3H), 0.88 (s, 3H), 0.87 (s, 3H), 0.83 (s, 3H)



**2-(4-bromo-2-fluorobenzyl)-cis-3-methyl-6-phenyl-1,2-thiazinane 1,1-dioxide [(±)-47]** Following the general oxidation and TMSOTf-promoted procedures, 2-(4-bromo-2-fluorobenzyl)-6-phenyl-1,2-thiazinane 1,1-dioxide **46** (120.3 mg, 0.302 mmol, 1.00 eq) in MeCN/DCM (1.2/0.3 mL) was oxidized with (*S,S*)-Mn(CF<sub>3</sub>PDP) (20.5 mg, 0.015 mmol, 0.05 eq), acetic acid (259 µL, 4.53 mmol, 15 eq), and H<sub>2</sub>O<sub>2</sub> (86 µL, 1.51 mmol, 5 eq, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL) at 0 °C via single addition protocol. Following oxidation plug, the mixture was purified via column chromatography to isolate the starting material from the oxidized products (50 mL silica, DCM loaded, 200 mL 0%  $\rightarrow$  5%  $\rightarrow$  15% EtOAc/hex). The starting material was resubmitted to the oxidation, and the oxidized products from both runs were combined and submitted to methylation with TFAA (43 µL, 0.302 mmol, 1.0 eq), TMSOTf (109 µL, 0.604 mmol, 2.0 eq) and AlMe<sub>3</sub> (2.0 M in hexanes, 453 µL, 0.906 mmol, 3.0 eq). Following workup, the crude material was purified by flash chromatography (50 mL silica, loaded with DCM, gradient elution 200 mL 0%  $\rightarrow$  2%  $\rightarrow$  4%  $\rightarrow$  6%  $\rightarrow$  8%  $\rightarrow$  10%  $\rightarrow$  20% EtOAc/Hex) to afford the product as a white solid.

**Run 1:** 24.9 mg, 0.0604 mmol, 20% yield; 23% rsm and > 20:1 dr by <sup>1</sup>H NMR.

**Run 2:** 31.1 mg, 0.0755 mmol, 25% yield; 22% rsm and > 20:1 dr by <sup>1</sup>H NMR.

**Run 3:** 27.4 mg, 0.0664 mmol, 22% yield; 23% rsm and > 20:1 dr by <sup>1</sup>H NMR.

## Average overall yield: 22% yield (23% rsm) ± 2.5, >20:1 dr.

Lower mass balance likely resulted from aromatic oxidation.

<sup>1</sup><u>H NMR:</u> (500 MHz, Chloroform-*d*)

δ 7.50 – 7.46 (m, 2H), 7.44 (t, *J* = 8.1 Hz, 1H), 7.42 – 7.36 (m, 3H), 7.33 (dd, *J* = 8.2, 1.8 Hz, 1H), 7.29 – 7.22 (m, 1H), 4.60 (d, *J* = 15.3 Hz, 1H), 4.39 (d, *J* = 15.4 Hz, 1H), 4.07 (dd, *J* = 12.5, 3.3 Hz, 1H), 3.59 (qt, *J* = 7.1, 3.6 Hz, 1H), 2.90 (dtd, *J* = 15.8, 13.1, 3.1 Hz, 1H), 2.26 – 2.12 (m, 1H), 2.05 (tdd, *J* = 13.6, 5.5, 3.6 Hz, 1H), 1.75 (m, 1H), 1.49 (d, *J* = 7.1 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, Chloroform-*d*)

δ 160.91 (d, *J* = 250.7 Hz), 132.33, 131.96 (d, *J* = 4.6 Hz), 129.71, 129.11, 128.83, 128.05 (d, *J* = 3.7 Hz), 123.83 (d, *J* = 14.3 Hz), 121.93 (d, *J* = 9.5 Hz), 119.19 (d, *J* = 25.1 Hz), 65.79, 55.70, 44.08 (d, *J* = 3.4 Hz), 29.60, 26.48, 17.40

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<sup>19</sup>F NMR: (471 MHz, Chloroform-d)
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 $\delta$  -116.50 (t, *J* = 8.7 Hz)

## HRMS: (ESI TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>20</sub>BrFNO<sub>2</sub>S [M+H]<sup>+</sup>: 412.0382, found 412.0358.

Relative stereochemistry was assigned by taking the product and cross-coupling to 1-acetylpiperazine (as described in the original publication) and comparing the NMR data to the published work<sup>5</sup>.

<sup>1</sup><u>H NMR:</u> (500 MHz, DMSO-*d*<sub>6</sub>)

δ 7.49 – 7.43 (m, 2H), 7.43 – 7.34 (m, 3H), 7.29 (t, *J* = 8.9 Hz, 1H), 6.84 – 6.74 (m, 2H), 4.41 – 4.37 (m, 3H), 3.61 – 3.46 (m, 5H), 3.22 (t, *J* = 5.2 Hz, 2H), 3.15 (t, *J* = 5.3 Hz, 2H), 2.77 – 2.65 (m, 1H), 2.14 – 1.98 (m, 5H), 1.66 – 1.55 (m, 1H), 1.34 (d, *J* = 7.1 Hz, 3H).



((4S,5R)-3-(3-fluoro-4-(6-(2-methyl-2H-tetrazol-5-yl)pyridin-3-yl)phenyl)-4-methyl-2-oxooxazolidin-5-yl)methyl acetate [49] According to a modified general oxidation procedure and the TFAA-promoted (R)-(3-(3-fluoro-4-(6-(2-methyl-2H-tetrazol-5-yl)pyridin-3-yl)phenyl)-2methylation procedure, oxooxazolidin-5-yl)methyl acetate 48 (82.5 mg, 0.20 mmol, 1.0 equiv.) and (S,S)-Mn(CF<sub>3</sub>PDP) (5.4 mg, 0.0040 mmol, 0.02 equiv.) in a 40-mL vial were dissolved in 2:1 MeCN/AcOH (3.0 mL, 0.067 M). The reaction mixture was then placed into an ice bath at 0°C. A 10 mL syringe was charged with a solution of H<sub>2</sub>O<sub>2</sub> (56.8 µL, 1.00 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (2.50 mL, 0.4 M). The syringe was then fitted with a 25G needle and the solution was slowly added into the stirring reaction mixture via a syringe pump at 2.50 mL/h. Upon completion, the vial was taken from the cold bath, and the reaction mixture was immediately loaded onto a 15 mL silica plug. Ethyl acetate was used to rinse the vial (2x1 mL), and the resulting washes were also loaded onto the silica plug. The plug was allowed to sit for five minutes in order to decompose any remaining hydrogen peroxide as well as absorbing the reaction mixture. Ethyl acetate (150 mL) was then allowed to pass through the plug and the eluent condensed. For facile isolation, the oxidation products were isolated from the crude by medium-pressure liquid chromatography (24 g silica, 50 column volumes  $0\% \rightarrow 10\%$  MeOH/CH<sub>2</sub>Cl<sub>2</sub>). The crude from oxidation was dissolved in CH<sub>2</sub>Cl<sub>2</sub> (1.0 mL, 0.2 M), backfilled with nitrogen 3x, and trifluoroacetic anhydride (27.8 µL, 42.0 mg, 0.20 mmol, 1.0 equiv.) was added. The reaction was stirred at room temperature for 1 h, and then placed into a -78 °C dry ice/acetone bath. Trimethylaluminum (2.0 M in hexanes, 300 µL, 0.90 mmol, 3.0 equiv.) and TMSOTf (72.7 µL, 88.9 mg, 0.40 mmol, 2.0 equiv.) were then added dropwise. The reaction mixture was stirred at -78 °C for 2 h, then allowed to warm to room temperature while stirring for 1 h. Upon completion, the reaction was diluted with  $CH_2Cl_2$  (5 mL) and poured into a 60 mL separatory funnel containing 3 mL 1 M NaOH for quenching. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over anhydrous MgSO<sub>4</sub>, filtered, and condensed in vacuo. Flash chromatography (20 mL silica, 200 mL EtOAc) afforded the product as a white solid as a mixture of diastereomers. The stereochemistry was determined by analogy to product 50.

Run 1 (33.4 mg, 0.0783 mmol, 39% yield, 3:1 dr; 25.0 mg, 0.0606 mmol, 30% rsm)

**Run 2** (33.0 mg, 0.0773 mmol, 39% yield, 3:1 dr; 22.5 mg, 0.0546 mmol, 27% rsm)

Run 3 (35.3 mg, 0.0829 mmol, 41% yield, 3:1 dr; 17.6 mg, 0.0427 mmol, 21% rsm)

## Average overall yield: 40% (26% rsm) ± 1.2, 3:1 dr

Methylation with Deoxo-Fluor: 4.9 mg, 0.012 mmol, 6% yield, 5:1 dr; 10.6 mg, 0.0261 mmol, 13% hemiaminal acetate; 14.7 mg, 0.0358 mmol, 18% enamine; 16.5 mg, 0.0400 mmol, 20% rsm

Methylation of isolated hemiaminal acetate intermediate [0.026 mmol scale] with BF<sub>3</sub>: 0% yield, 5% rsm by <sup>1</sup>H NMR

Characterization of major diastereomer 49:

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.94 (s, 1H), 8.32 (dd, *J* = 8.1, 0.9 Hz, 1H), 8.06 (dt, *J* = 8.2, 1.8 Hz, 1H), 7.52 (t, *J* = 8.5 Hz, 1H), 7.46 (dd, *J* = 12.4, 2.2 Hz, 1H), 7.34 (dd, *J* = 8.5, 2.2 Hz, 1H), 4.48 (s, 3H), 4.46-4.41 (m, 1H), 4.38-4.30 (m, 3H), 1.45 (d, *J* = 6.2 Hz, 3H)

<sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.67, 164.82, 160.27 (d, *J* = 249.5 Hz), 154.09, 150.00 (d, *J* = 3.4 Hz), 145.78, 138.51 (d, *J* = 10.9 Hz), 137.33 (d, *J* = 3.8 Hz), 132.26 (d, *J* = 1.8 Hz), 130.86 (d, *J* = 4.6 Hz), 122.17, 121.44 (d, *J* = 13.8 Hz), 116.74 (d, *J* = 3.4 Hz), 109.28 (d, *J* = 27.3 Hz), 77.71, 63.66, 54.21, 39.91, 20.81, 18.79

<sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

δ -114.90 (app t, J = 9.2 Hz)

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>20</sub>H<sub>20</sub>N<sub>6</sub>O<sub>4</sub>F [M+H]<sup>+</sup>: 427.1530, found 427.1532.

 $[\alpha]_{D}^{24} = -52.9^{\circ} (c = 0.67, CH_2Cl_2)$ 



# (4*S*,5*R*)-3-(3-fluoro-4-(6-(2-methyl-2*H*-tetrazol-5-yl)pyridin-3-yl)phenyl)-5-(hydroxymethyl)-4-

**methyloxazolidin-2-one [50]** In a 10-mL round-bottom flask containing ((4S,5R)-3-(3-fluoro-4-(6-(2-methyl-2H-tetrazol-5-yl)pyridin-3-yl)phenyl)-4-methyl-2-oxooxazolidin-5-yl)methyl acetate**49**as the major diastereomer (10.7 mg, 0.025 mmol, 1.0 equiv.) was added 1 M NaOH in methanol (0.25 mL, 0.25 mmol, 10 equiv.). The reaction mixture was stirred for 1 h at room temperature and directly loaded onto

column and purified by flash chromatography (20 mL silica, 200 mL  $0\% \rightarrow 100$  mL 5% EtOAc/MeOH) to afford the product as a white foam (8.8 mg, 0.023 mmol, 92% yield). The stereochemistry was determined by <sup>1</sup>H NMR, COSY, and NOESY 1D methods.

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.92 (s, 1H), 8.30 (d, *J* = 8.2 Hz, 1H), 8.04 (dt, *J* = 8.2, 1.8 Hz, 1H), 7.52 (t, *J* = 8.5 Hz, 1H), 7.49 (dd, *J* = 12.4, 2.1 Hz, 1H), 7.34 (dd, *J* = 8.9, 2.1 Hz, 1H), 4.52-4.47 (m, 1H), 4.47 (s, 3H), 4.31 (dt, *J* = 5.6, 3.7 Hz, 1H), 4.01 (d, *J* = 12.7, 3.3 Hz, 1H), 3.81 (d, *J* = 11.4 Hz, 1H), 2.26 (br s, 1H), 1.45 (d, *J* = 6.2 Hz, 3H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 164.85, 160.20 (d, *J* = 249.5 Hz), 154.69, 150.02 (d, *J* = 3.0 Hz), 145.73, 138.64 (d, *J* = 10.6 Hz), 137.25 (d, *J* = 3.8 Hz), 132.31, 130.73 (d, *J* = 4.4 Hz), 122.15, 121.37 (d, *J* = 13.3 Hz), 117.07 (d, *J* = 3.4 Hz), 109.55 (d, *J* = 27.0 Hz), 80.65, 62.34, 53.21, 39.89, 18.68

# <sup>19</sup>F NMR: (470 MHz, CDCl<sub>3</sub>)

 $\delta$  -114.67 (dd, J = 12.3, 8.7 Hz)

# HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>18</sub>H<sub>18</sub>N<sub>6</sub>O<sub>3</sub>F [M+H]<sup>+</sup>: 385.1424, found 385.1413.

 $[\alpha]_{D}^{24} = -49.2^{\circ} (c = 0.44, CH_2Cl_2)$ 



For COSY and NOESY see Supporting Information: Spectral Data



Methyl (3'-((1-(3,4-dichlorophenyl)ethyl)amino)-3-methyl-[1,1'-biphenyl]-4-carbonyl)-*L*-alaninate [52] To a 40 mL vial equipped with a stir bar were added methyl (3'-((3,4-dichlorobenzyl)amino)-3-methyl-[1,1'-biphenyl]-4-carbonyl)-*L*-alaninate 51 (141.4 mg, 0.30 mmol, 1.0 equiv,), (*S*,*S*)-Mn(CF<sub>3</sub>PDP)

(8.1 mg, 0.0060 mmol, 0.02 equiv.), MeCN (1.8 mL, 0.17 M), and AcOH (257 µL, 4.50 mmol, 15.0 equiv.). The reaction mixture was heated on 70 °C hot plate until fully dissolved, then placed into an ice bath at 0°C. A 10 mL syringe was charged with a solution of  $H_2O_2$  (85.2  $\mu$ L, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in MeCN (3.75 mL, 0.4 M). The syringe was then fitted with a 25G needle and the solution was slowly added into the stirring reaction mixture via a syringe pump at 3.75 mL/h. Upon completion, the vial was taken from the cold bath, and the reaction mixture was immediately loaded onto a 15 mL silica plug. Ethyl acetate was used to rinse the vial (2x1 mL), and the resulting washes were also loaded onto the silica plug. The plug was allowed to sit for five minutes in order to decompose any remaining hydrogen peroxide as well as absorbing the reaction mixture. Ethyl acetate (150 mL) was then allowed to pass through the plug, and the eluent was concentrated in vacuo. The recovered starting material was isolated by flash chromatography (dry loading, 50 mL silica, gradient elution 400 mL 30% -> 500 mL 40% EtOAc/Hex). All other fractions were combined, condensed in vacuo, transferred into a 25 mL recovery flask, condensed, and placed on vacuum overnight. To the same recovery flask was then added CH<sub>2</sub>Cl<sub>2</sub> (1.5 mL) and flame-dried 5 Å powdered molecular sieves (40 mg). The flask was again placed in ice bath, backfilled with N2 3x, and TMSOTf (1.2 equiv. to crude imine) was added dropwise. The reaction was allowed to stir at 0 °C for 1 h, then placed into a -78 °C cold bath. Methylmagnesium bromide (3 M, 3.0 equiv. to crude imine) was then added, and the reaction was stirred at -78 °C for 4 h. Water (100 µL) was added to quench the reaction, which was then warmed to room temperature in a water bath. The crude was transferred to a 20 mL Erlenmeyer flask, dried over MgSO4, and condensed in vacuo. It was observed by crude <sup>1</sup>H NMR that there was unreacted imine. The crude was transferred into a 25 mL recovery flask, placed on vacuum overnight, and resubjected 1x to same amounts of TMSOTf and MeMgBr. Following workup, the crude material was purified by medium-pressure liquid chromatography (12 g silica, 50 column volumes gradient elution  $0\% \rightarrow 50\%$  EtOAc/Hex) to afford the product as a white foam.

Run 1 (18.6 mg, 0.0383 mmol, 13% yield; 16.4 mg, 0.0349 mmol, 12% recovered imine)

**Run 2** (22.3 mg, 0.0459 mmol, 15% yield; 20.0 mg, 0.0426 mmol, 14% recovered imine; 1.5 mg, 0.0032 mmol, 1% rsm)

**Run 3** (20.8 mg, 0.0428 mmol, 14% yield; 19.0 mg, 0.0405 mmol, 13% recovered imine; 1.5 mg, 0.0032 mmol, 1% rsm)

## Average overall yield: 14% (1% rsm) ± 1.0; 13% recovered imine

Lower mass balance resulted from aromatic oxidation and hydrolysis of the imine intermediate during oxidation, which formed aldehyde product that was subsequently oxidized to carboxylic acid.

#### <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 7.50 (d, *J* = 2.1 Hz, 1H), 7.45 (d, *J* = 8.4 Hz, 1H), 7.40 (d, *J* = 8.2 Hz, 1H), 7.33-7.28 (m, 2H), 7.24 (dd, *J* = 8.2, 2.1 Hz, 1H), 7.17 (t, *J* = 7.8 Hz, 1H), 6.89 (d, *J* = 7.6 Hz, 1H), 6.69 (s, 1H),

6.45 (d, *J* = 8.0, 2.3 Hz, 1H), 6.36 (d, *J* = 7.6 Hz, 1H), 4.81 (p, *J* = 7.2 Hz, 1H), 4.48 (q, *J* = 6.7 Hz, 1H), 4.14 (br s, 1H), 3.80 (s, 3H), 2.50 (s, 3H), 1.53 (d, *J* = 7.4 Hz, 6H) <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 173.65, 169.37, 147.18, 145.82, 143.45, 141.47, 136.90, 134.48, 132.93, 130.92, 130.88, 130.00, 129.81, 128.08, 127.52, 125.43, 124.53, 117.03, 112.76, 112.46, 53.08, 52.70, 48.48, 25.10, 20.18, 18.75

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>26</sub>H<sub>27</sub>N<sub>2</sub>O<sub>3</sub>Cl<sub>2</sub> [M+H]<sup>+</sup>: 485.1399, found 485.1393.



(3R,5R,6S,8R,9S,10S,13S,14S,17S)-6,10,13-trimethyl-17-(pyridin-3-yl)hexadecahydro-1H-

cyclopenta[a]phenanthren-3-yl acetate [(+)-54] According to a modified general oxidation procedure, added (3R,5S,8R,9S,10S,13S,14S,17S)-10,13-dimethyl-17-(pyridin-3in а 40-mL vial was yl)hexadecahydro-1*H*-cyclopenta[a]phenanthren-3-yl acetate (+)-53 (118.7 mg, 0.30 mmol, 1.0 equiv.), CH<sub>2</sub>Cl<sub>2</sub> (1.2 mL), and HBF<sub>4</sub>•OEt<sub>2</sub> (44.9 µL, 0.33 mmol, 1.1 equiv.). The reaction mixture was stirred for 1 h, and the solvent was removed in vacuo. The crude was placed on high vacuum overnight to remove the residual acid. (R,R)-Mn(CF<sub>3</sub>PDP) (40.7 mg, 0.030 mmol, 0.10 equiv.) and ClCH<sub>2</sub>COOH (425 mg, 4.50 mmol, 15.0 equiv.) were added to the crude, and the mixture was dissolved in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (1 mL, 0.3 M) and placed in a -36 °C dry ice/1,2-DCE bath. A 10 mL syringe was charged with a solution of H<sub>2</sub>O<sub>2</sub> (85.2 µL, 1.50 mmol, 5.0 equiv, 50 wt.% in H<sub>2</sub>O) in 4:1 MeCN/CH<sub>2</sub>Cl<sub>2</sub> (3.75 mL, 0.4 M). The syringe was then fitted with a 25G needle and the solution was slowly added into the stirring reaction mixture over 3 h via a syringe pump at 1.25 mL/h. Following oxidation, the reaction mixture was diluted with CH<sub>2</sub>Cl<sub>2</sub> (5 mL) and cooled to 0 °C. 3 M NaOH (5 mL) was added, and the mixture was stirred vigorously for 5 min. The layers were separated and the aqueous layer was extracted with  $CH_2Cl_2$  (2x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. For facile isolation, the alcohol product was isolated by medium-pressure liquid chromatography (12 g silica, 100 column

volumes 0% $\rightarrow$ 70% EtOAc/Hex), and redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1 mL). MsCl (23.2 µL, 34.4 mg, 0.30 mmol, 1.0 equiv.) was added, followed by Et<sub>3</sub>N (41.8 µL, 30.4 mg, 0.30 mmol, 1.0 equiv.). The reaction was stirred at room temperature for 1 h, then partitioned between sat. NaHCO<sub>3</sub> and CH<sub>2</sub>Cl<sub>2</sub>. The layers were separated and the aqueous layer was extracted wit CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo, then redissolved in CH<sub>2</sub>Cl<sub>2</sub> (1 mL) and cooled to -78 °C. Trimethylaluminum (2.0 M in hexanes, 450 µL, 0.90 mmol, 3.0 equiv.) was then added, and the reaction was stirred at -78 °C for 2 h and room temperature for 1 h. Upon completion, the mixture was diluted the CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in Vacuo (5 mL). The layers were separated and the aqueous layer was extracted wit CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were diluted the CH<sub>2</sub>Cl<sub>2</sub> (2x5 mL). The organic layers were combined, dried over MgSO<sub>4</sub>, and condensed in vacuo. The crude material was purified by flash chromatography (20 mL silica, 200 mL 20% EtOAc/Hex) to afford the product as a white solid. Stereochemistry was assigned by <sup>1</sup>H NMR, COSY, and 1D NOESY methods on the product's deacetylated derivative **S46**.

**Run 1** (16.7 mg, 0.0408 mmol, 14% yield, >20:1 dr; 11.8 mg, 0.0298 mmol, 10% rsm; 24.2 mg, 0.059 mmol, 20% ketone)

**Run 2** (19.0 mg, 0.0464 mmol, 15% yield, >20:1 dr; 24.9 mg, 0.0629 mmol, 21% rsm; 15.6 mg, 0.038 mmol, 13% ketone)

**Run 3** (21.5 mg, 0.0525 mmol, 17% yield, >20:1 dr; 23.5 mg, 0.0594 mmol, 20% rsm; 17.2 mg, 0.042 mmol, 14% ketone)

## Average overall yield: 15% (17% rsm) ± 1.5, >20:1 dr; 16% ketone

An average of 32% desired alcohol intermediate was produced in the oxidation. Lower mass balance partially resulted from the more challenging methylation procedure: approximately 80% yield in mesylation of the alcohol, and approximately 68% yield in methylation of the mesylate.

# <sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.49-8.41 (m, 2H), 7.54 (dt, *J* = 8.0, 2.0 Hz, 1H), 7.23 (dd, *J* = 7.9, 4.8 Hz, 1H), 5.05 (p, *J* = 2.9 Hz, 1H), 2.67 (t, *J* = 9.9 Hz, 1H), 2.11-1.92 (m, 2H), 2.06 (s, 3H), 1.87-1.77 (m, 2H), 1.74-1.66 (m, 2H), 1.66-1.43 (m, 5H), 1.42-1.05 (m, 8H), 0.86-0.80 (m, 1H), 0.79 (s, 3H), 0.79 (d, *J* = 6.6 Hz, 3H), 0.71 (q, *J* = 12.2 Hz, 1H), 0.47 (s, 3H)

## <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 170.84, 150.42, 147.50, 136.66, 135.85, 122.90, 70.05, 56.42, 54.67, 54.51, 46.52, 44.58, 41.93, 37.74, 36.15, 35.59, 33.20, 30.93, 28.93, 26.03, 25.93, 24.51, 21.73, 20.55, 20.38, 12.92, 12.51

HRMS: (ESI-TOF MS ES+)

m/z calculated for C<sub>27</sub>H<sub>40</sub>NO<sub>2</sub> [M+H]<sup>+</sup>: 410.3059, found 410.3052. [ $\alpha$ ]<sub>D</sub><sup>24</sup> = +13.3° (c = 0.95, CH<sub>2</sub>Cl<sub>2</sub>) For COSY and HSQC see Supporting Information: Spectral Data



## (3R,5R,6S,8R,9S,10S,13S,14S,17S)-6,10,13-trimethyl-17-(pyridin-3-yl)hexadecahydro-1H-

cyclopenta[*a*]phenanthren-3-ol [S46] Prepared by reacting 54 (7.5 mg, 0.018 mmol, 1.0 equiv.) with 1 M NaOH/MeOH (1 mL, 6 h at room temperature), the reaction mixture was partitioned between water and  $CH_2Cl_2$ , the aqueous layer was extracted with  $CH_2Cl_2$  2x. The organic layers were combined, dried over MgSO<sub>4</sub>, filtered, and condensed in vacuo to afford S46 as a white solid (5.4 mg, 0.015 mmol, 83% yield). The stereochemistry was determined by <sup>1</sup>H NMR, COSY, and 1D NOESY methods.

<sup>1</sup><u>H NMR:</u> (500 MHz, CDCl<sub>3</sub>)

δ 8.55-8.30 (br s, 2H), 7.52 (d, J = 7.9 Hz, 1H), 7.23 (dd, J = 7.1, 4.9 Hz, 1H), 4.07 (br s, 1H), 2.67 (t, J = 9.8 Hz, 1H), 2.07 (dtd, J = 14.5, 11.1, 3.7 Hz, 1H), 2.01-1.92 (m, 1H), 1.86-1.79 (m, 1H), 1.77 (dq, J = 14.3, 3.0 Hz, 1H), 1.73-1.66 (m, 2H), 1.65-1.56 (m, 3H), 1.54 (dt, J = 11.5, 3.1 Hz, 1H), 1.51-1.42 (m, 2H), 1.40-1.25 (m, 5H), 1.24-1.10 (m, 3H), 0.88-0.82 (m, 1H), 0.82 (d, J = 6.6 Hz, 3H), 0.78 (s, 3H), 0.71 (q, J = 12.2 Hz, 1H), 0.47 (s, 3H)

# <sup>13</sup>C NMR: (126 MHz, CDCl<sub>3</sub>)

δ 150.47, 147.51, 135.84, 122.47, 66.54, 56.42, 54.66, 54.64, 45.64, 44.58, 42.01, 37.76, 36.46, 35.63, 32.49, 31.81, 31.00, 28.81, 26.04, 24.52, 20.54, 20.40, 12.93, 12.35



For COSY and NOESY see Supporting Information: Spectral Data

# VII. HPLC traces for the determination of product stereoretention



HPLC (Chiralcel OJ-H, 1.0 mL/min, 30 °C, 98:2 Hex:iPrOH) trace for the racemic starting material:





HPLC (Chiralcel OJ-H, 1.0 mL/min, 30 °C, 98:2 Hex:iPrOH) trace for chiral starting material S11:



>99% ee according to the HPLC trace integration.



HPLC (Chiralcel OJ-H, 1.0 mL/min, 30 °C, 98:2 Hex:iPrOH) trace for the racemic methylation product:



Totals :

1.13622e4 155.19114



HPLC (Chiralcel OJ-H, 1.0 mL/min, 30 °C, 98:2 Hex:iPrOH) trace for chiral product 12:



Signal 1: DAD	01 A, Sig=254,	4 Ref=off		
Peak RetTime # [min]	Type Width [min]	Area [mAU*s]	Height [mAU]	Area %
1 33.114	BB 0.8127	 2985.09937	 51.92839	30.7456
2 37.294	BB 1.0159	6723.92285	101.04995	69.2544
Totals :		9709.02222	152.97834	

>99% ee according to the HPLC trace integration, 100% es.



HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the racemic starting material:





HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the chiral starting material **\$12**:



93% ee according to the HPLC trace integration.



HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the racemic major product:





HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the chiral major product **13**:



93% ee according to the HPLC trace integration, 100% es.


## HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the racemic minor product:





HPLC trace (AD-RH Reverse Phase Chiral, 1.0 mL/min, 30 °C, 35:65 MeCN:H<sub>2</sub>O) for the chiral minor product **S28**:



93% ee according to the HPLC trace integration, 100% es.

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5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2

	Parameter	Value				Å –
1	Origin	Bruker BioSpin GmbH			1	
2	Spectrometer	spect			i	
3	Solvent	CDCI3				ОП
4	Temperature	296.1				
5	Pulse Sequence	zgpg30				
6	Experiment	1D				
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)				
8	Number of Scans	368				
9	Receiver Gain	190.5				
10	Relaxation Delay	2.0000				
11	Pulse Width	10.0000				
12	Acquisition Time	1.0398				
13	Spectrometer Frequency	125.83				
14	Spectral Width	31512.6				
15	Lowest Frequency	-1916.9				
16	Nucleus	13C				
17	Acquired Size	32768	1			
18	Spectral Size	65536				
					1	
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1OriginVarianVarian2Spectrometerinova3SolventCDCl34Temperature20.05Pulse Sequence52pul6Experiment1D7Probequadbp8Number of Scans169Receiver Gain5210Relaxation Delay0.000011Pulse Width5.825012Acquisition Time4.096013Spectrometer397.4Frequency-2427.914Spectral Width8000.015Lowest Frequency-2427.916Nucleus1H17Acquired Size3276818Spectral Size65536	Parameter	Value
2Spectrometerinova3SolventCDCl34Temperature20.05Pulse Sequences2pul6Experiment1D7Probequadbp8Number of Scans169Receiver Gain5210Relaxation Delay0.000011Pulse Width5.825012Acquisition Time4.096013Spectrometer39.74Frequency-2427.916Nucleus1H17Acquired Size3276818Spectral Size65536	1 Origin	Varian
3 Solvent CDCl3   4 Temperature 20.0   5 Pulse Sequence 32pul   6 Experiment 1D   7 Probe quadbp   8 Number of Scans 16   9 Receiver Gain 52   10 Relaxation Delay 0.0000   11 Pulse Width 5.8250   12 Acquisition Time 4.0960   13 Spectrometer 399.74   Frequency -2427.9   16 Nucleus 1H   17 Acquired Size 32768   18 Spectral Size 65536	2 Spectrometer	inova
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6 Experiment 1D   7 Probe quadbp   8 Number of Scans 16   9 Receiver Gain 52   10 Relaxation Delay 0.0000   11 Pulse Width 5.8250   12 Acquisition Time 4.0960   13 Spectrometer 399.74   Frequency -2427.9   16 Nucleus 1H   17 Acquired Size 32768   18 Spectral Size 65536	5 Pulse Sequence	s2pul
7Probequadbp8Number of Scans169Receiver Gain5210Relaxation Delay0.000011Pulse Width5.825012Acquisition Time4.096013Spectrometer Frequency399.7414Spectrometer Frequency-2427.916Nucleus1H17Acquired Size3276818Spectral Size65536	6 Experiment	1D
8 Number of Scans 16   9 Receiver Gain 52   10 Relaxation Delay 0.0000   11 Pulse Width 5.8250   12 Acquisition Time 4.0960   13 Spectrometer 399.74   Frequency -2427.9   16 Nucleus 1H   17 Acquised Size 32768   18 Spectral Size 65536	7 Probe	quadbp
9 Receiver Gain 52   10 Relaxation Delay 0.0000   11 Pulse Width 5.8250   12 Acquisition Time 4.0960   13 Spectrometer 399.74   Frequency -2427.9   16 Nucleus 1H   17 Acquired Size 32768   18 Spectral Size 65536	8 Number of Scans	16
10 Relaxation Delay 0.0000   11 Pulse Width 5.8250   12 Acquisition Time 4.0960   13 Spectrometer Frequency 399.74   14 Spectral Width 8000.0   15 Lowest Frequency -2427.9   16 Nucleus 1H   17 Acquired Size 32768   18 Spectral Size 65536	9 Receiver Gain	52
11 Pulse Width5.825012 Acquisition Time4.096013 Spectrometer Frequency399.7414 Spectral Width8000.015 Lowest Frequency-2427.916 Nucleus1H17 Acquired Size3276818 Spectral Size65536	10 Relaxation Delay	0.0000
12 Acquisition Time4.096013 Spectrometer Frequency399.7414 Spectral Width8000.015 Lowest Frequency-2427.916 Nucleus1H17 Acquired Size3276818 Spectral Size65536	11 Pulse Width	5.8250
13 Spectrometer Frequency399.7414 Spectral Width8000.015 Lowest Frequency-2427.916 Nucleus1H17 Acquired Size3276818 Spectral Size65536	12 Acquisition Time	4.0960
14 Spectral Width8000.015 Lowest Frequency-2427.916 Nucleus1H17 Acquired Size3276818 Spectral Size65536	13 Spectrometer Frequency	399.74
15 Lowest Frequency-2427.916 Nucleus1H17 Acquired Size3276818 Spectral Size65536	14 Spectral Width	8000.0
16 Nucleus 1H   17 Acquired Size 32768   18 Spectral Size 65536	15 Lowest Frequency	-2427.9
17 Acquired Size 32768   18 Spectral Size 65536	16 Nucleus	1H
18 Spectral Size 65536	17 Acquired Size	32768
	18 Spectral Size	65536

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value					l _
1	Origin	Bruker BioSpin GmbH			7 16		
2	Spectrometer	spect			, L		T L
3	Solvent	CDCI3			i		UAC
4	Temperature	296.2					
5	Pulse Sequence	zgpg30					
6	Experiment	1D					
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					
8	Number of Scans	128					
9	Receiver Gain	190.5					
10	Relaxation Delay	2.0000					
11	Pulse Width	10.0000					
12	Acquisition Time	1.0398					
13	Spectrometer Frequency	125.83					
14	Spectral Width	31512.6					
15	Lowest Frequency	-1916.9					
16	Nucleus	13C					
17	Acquired Size	32768					
18	Spectral Size	65536					
						11	
						I , , , , , , , , , , , , , , , , , , ,	,
*****	₩₽₩₽₩₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩₽₩	฿๛๚๛๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚๚	984)[e=41/381/98	<sup>เ</sup> รือการเกิดสารใหม่งที่มาเป็นแหน่งการทำงานไทยและมีมีและสารให้แปรโมครามการเห็นขึ้นและเห็นแหนูสมารุโหนด	w.Agentingtal	ะงามของของครองกระบาทการและของสมาร์สารสารสารสารสารสารสารสารสารสารสารสารสารส	alan yang kanan

-1 f1 (ppm) Ó

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Parameter	Value
1 Origin	Varian
2 Spectrometer	inova
3 Solvent	CDCI3
4 Temperature	20.0
5 Pulse Sequence	s2pul
6 Experiment	1D
7 Probe	QUADG
8 Number of Scans	16
9 Receiver Gain	44
10 Relaxation Delay	10.0000
11 Pulse Width	12.1250
12 Acquisition Time	4.0960
13 Spectrometer Frequency	499.43
14 Spectral Width	8000.0
15 Lowest Frequency	-1502.8
16 Nucleus	1H
17 Acquired Size	32768
18 Spectral Size	65536

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

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Parameter	Value			CDCI3		
1 Origin	Varian			7.16		
2 Spectrometer	inova			~ _		Me
3 Solvent	CDCI3			I		
4 Temperature	20.0					
5 Pulse Sequence	s2pul					
6 Experiment	1D					
7 Probe	QUADG					
8 Number of Scans	96					
9 Receiver Gain	60					
10 Relaxation Delay	2.0000					
11 Pulse Width	6.1250					
12 Acquisition Time	1.0240					
13 Spectrometer Frequency	125.60					
14 Spectral Width	32000.0					
15 Lowest Frequency	-2206.8		1			
16 Nucleus	13C					
17 Acquired Size	32768					
18 Spectral Size	65536	1911), 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 1944, 19	n feli an an ai kun bian dan isti da inu di muan niyu sekun dan bia	an with the line of a standard with the standard in the standa		un this collection and a state of a state of the
a kontanta kana kana kana kana kana kana kan	איזארארארארארארארארארארארארארארארארארארא	hardnin yn heenda waar de en de ferske fryf yn fryf fer fry	nal an	aduda maariin dahadid iyo ya kaa kaadia dhaada ah	lak terdak pérdak tahun di kalan di ka Ang terdak di kalan di	alhaiteatilisteitikkinkinkinkinkinkinkinkinkinkinkinkinki

Parameter	Value	CDCI3	Å –
1 Origin	Varian	7.26	
2 Spectrometer	inova		I C
3 Solvent	CDCI3		0
4 Temperature	20.0		
5 Pulse Sequence	s2pul		
6 Experiment	1D		
7 Probe	hcn		
8 Number of Scans	16		
9 Receiver Gain	38		
10 Relaxation Delay	0.0000		
11 Pulse Width	7.0000		
12 Acquisition Time	4.0960		
13 Spectrometer Frequency	500.06		
14 Spectral Width	8000.0		
15 Lowest Frequency	-1513.1		
16 Nucleus	1H		
17 Acquired Size	32768		
18 Spectral Size	65536		
			Grease

...0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0 f1 (ppm)

Parameter	Value				Ĺ	
1 Origin	Bruker BioSpin GmbH			P T	L N	-{ }-ci
2 Spectrometer	spect		ł		1	
3 Solvent	CDCI3					
4 Temperature	296.2					
5 Pulse Sequence	zgpg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z	)				
8 Number of Scans	368					
9 Receiver Gain	190.5					
10 Relaxation Delay	2.0000					
11 Pulse Width	10.0000					
12 Acquisition Time	1.0398					
13 Spectrometer Frequency	125.83					
14 Spectral Width	31512.6					
15 Lowest Frequency	-1898.7					
16 Nucleus	13C					
17 Acquired Size	32768					
18 Spectral Size	65536					
					<b>. . . .</b>	
nallyyedd ar	an a	wininali (winfui latimia)	Hilderichten aufersteinen einer Verseherten auferteinen hieft nem Kannan der Kannan der Kannan der Kannan der K Kannan der Kannan der Ka	r muunuunuunuunuunuunuunuunuu	inen jaarnije van de fallen die kennen die het in die de de de die die die die die die di	li pinang langada kanang kang pang pinang pinang Kang pinang pi

Parameter	Value	CDCI3	.H2Cl2	12 0	~ ~
1 Origin	Varian	26 C	30 C	26 H	
2 Spectrometer	inova		ю́ I	i I	
3 Solvent	CDCI3	Ι	I	I	
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	hcn				
8 Number of Scans	16				
9 Receiver Gain	44				
10 Relaxation Delay	0.0000				
11 Pulse Width	7.0000				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	500.07				
14 Spectral Width	8000.0				
15 Lowest Frequency	-1521.6				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
		1			
			! /' /'	N. In the second s	

.. 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)



5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 6.5 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 7.0 6.0 1.0

1 Origin Bruker BloSpin GmbH   2 Spectrometer spectric   3 Solvent CDSCN   4 Temperature 295.1   5 Nulse Square zgg30   6 Experiment ID   7 Probe 2127784_0002 (CP B80 50051 B8F-H-D-05 Z)   8 Number of Scans 368   9 Reckver Gain 190.5   10 Relaxation Delay 2.0000   11 Pulse Width 10.0000   12 Arquired Size 32768   13 Spectromet Frequency 1.338   13 Spectral Width 31512.6   15 Lowest Frequency 32768   13 Spectral Size 3268		Parameter	Value				<del>CD3CN</del>
2 Spectrometer spect ort   3 Solvent C0SON   4 Temperature 296.1   5 Pulse Sequence 20930   6 Experiment ID   7 Probe Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)   8 Number of Scans 368   9 Reciver Caint 190.5   10 Relaxation Delay 2.0000   11 Pulse Width 10.0398   13 Spectrometer Frequency 125.83   14 Spectral Width 31512.6   15 Lowest Frequency -1798.9   16 Nucleus 13C   17 Acquired Size 25768   18 Spectral Widt 3151.2   15 Lowest frequency -1798.9   16 Nucleus 13C   17 Acquired Size 65536	1 0	rigin	Bruker BioSpin GmbH				ч Ч
3 Solvent CD3CN   4 Temperature 296.1   5 Pulse Sequence 29030   6 Experiment 10   7 Probe 212778.0002 (CP BB0 500S1 BBF-H-D-05 Z)   8 Number of Scans 368   9 Receiver Cain 190.5   10 Relaxation Data 20000   11 Pulse Wridth 10.0000   12 Acquistion Time 1.0398   13 Spectrometrefrequenty 25.83   14 Spectral Wridth 31512.6   15 Lowest Frequenty 1778.9   16 Nucledis 32.788   17 Acquired Size 32.56   18 Spectrate Size 653.6	2 Sp	pectrometer	spect				<del>1</del> 8
4 Temperature   295.1     5 Pulse Sequence   29900     6 Experimence   227784_0002 (CP BB0 50051 BBF-H-D-O 5 Z)     7 Pobe   2127784_0020 (CP BB0 50051 BBF-H-D-O 5 Z)     8 Number of Stans   368     9 Receiver Gain   190.5     10 Relaxition Delay   2.0000     11 Pulse With   0.0000     12 Acquisition Time   0.0398     13 Spectramiter Frequency   1512.6     14 Spectramiter Time   1378.9     15 Lowest Frequency   3778.9     17 Acquired Size   536	3 So	olvent	CD3CN				
5   Pulse Sequence   zpp30     6   Experiment   1D     7   Probe   Z127784_0002 (CP BBO 50051 BBF-H-D-O 5 Z)     8   Number of Scans   368     9   Receiver Gain   190.5     10   Relaxino Delay   2.0000     11   Pulse Width   10.0000     12   Acquisition Time   10.398     13   Spectrometer Frequency   125.83     14   Spectral Width   31512.6     15   Lowest Frequency   1378.9     16   Nucleus   32768     17   Acquised Size   5536	4 Te	emperature	296.1				
6 Experiment 10   7 Probe 2127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)   8 Number of Scans 368   9 Reclver Gain 100.5   10 Relaxation Delay 2.000   11 Pulse Ward 10.000   12 Reclver Gain 0.0398   13 Spectrometer Frequency 25.83   14 Spectrometer Frequency 4.798.9   15 Lowest Frequency 32768   16 Nucleus 32   17 Acquiristics 3536	5 Pi	ulse Sequence	zgpg30				
7   Probe   2127784_0002 (CP 8B0 50051 8BF-H-D-05 2)     8   Number of Scan   368     9   Receiver Gain   190.5     10   Relaxiton Delay   2.0000     11   Pulse Width   0.0398     12   Acquistion Time   1.0398     13   Spectrometer Frequency   127.83     14   Spectrometer Frequency   179.8-     15   Lowest Frequency   179.8-     16   Nucleus   32768     17   Acquired Size   32768     18   Spectral Size   6536	6 E>	xperiment	1D				
8   Number of Scans   368     9   Receiver Gain   390.5     10   Relaxation Delay   2.0000     11   Pulse Width   10.0000     12   Acquisition Time   0.0398     13   Spectrometer Frequeny 125.83   1512.6     14   Spectral Width   31512.6     15   Isovers Frequeny 125.83   161     16   Nucleus   1352.6     15   Spectral Width   31512.6     15   Nucleus   1352.6     16   Nucleus   1352.6     17   Acquired Size   22768     18   Spectral Size   65336	7 Pr	robe	Z127784_0002 (CP BBO 500S	1 BBF-H-D-05	Z)		
9   Reciver Cain   100.5     10   Relaxation Delay   2.0000     11   Pulse Width   10.0000     12   Acquisition Time   1.0398     13   Spectrometer Frequency   125.83     14   Spectral Width   31512.6     15   Lowest Frequency   1-798.9     16   Nucleus   32     17   Acquired Size   32768     18   Spectral Size   65336	8 N	umber of Scans	368				
10 Relaxation Delay 2.000   11 Puise Width 0.0000   12 Acquisition Time 1.0398   13 Spectrometer Frequency 125.83   14 Spectral Width 3151.6   15 Lovest Frequency 1798.9   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 6536	9 R	eceiver Gain	190.5		I		
11 Puke Width 10.000   12 Acquisition Time 1.0398   13 Spectrometer Frequency 125.83   14 Spectral Width 31512.6   15 Lowest Frequency -1798.9   16 Nucleus 136   17 Acquired Size 22768   18 Spectral Size 6536	10 R	elaxation Delay	2.0000				
12 Acquisition Time 1.0398   13 Spectrometer Frequeny 125.83   14 Spectral Width 31512.6   15 Lowest Frequeny -1798.9   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 65536	11 Pu	ulse Width	10.0000				
13 Spectrometer Frequency 125.83   14 Spectral Width 31512.6   15 Lowest Frequency -1798.9   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 6536	12 A	cquisition Time	1.0398				
14 Spectral Width 31512.6   15 Lowest Frequency -1798.9   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 65336	13 Sp	pectrometer Frequency	125.83				
15 Lowset Frequency -1798.9   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 65336	14 Sp	pectral Width	31512.6				
16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 65536	15 Lo	owest Frequency	-1798.9				
17 Acquired Size 32768   18 Spectral Size 65536	16 N	ucleus	13C				
18 Spectral Size 65536	17 A	cquired Size	32768				
	18 Sp	pectral Size	65536				
	anna ann ann ann ann ann ann ann ann an	ĨĸġĸĸġŊŗŊĸĸĸĬĸĸġĊĸĸġĊĸſġĸĸġĸĸġĊĸŶĸĊĸĸĸĊĸĸţĬĸĸĸŀĸĸĬĸĸĸĬĸĸĸĬĸĿĸĬ ĨĸġĸĸġŊŗŊĸĸĸĬĸĸġĊĸĸġĊĸĸſġĸĸġĸĸĸġĬĸĸĊĸĸĬĸĸĸĸĬĸĸĸĬĸĸĸĬĸĿĸĬ	lyonanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyez Nevezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanyezhanye	enterenterenterenterenterenterenterente	nondini/Mono	aduvilavi	Minyw <sup>(</sup> )



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 7.0 6.5 6.0 1.0 f1 (ppm)

	Parameter	Value			<del>1</del> 10 10			
1	Origin	Bruker BioSpin GmbH			- F			
2	Spectrometer	spect			r-			OAc
3	Solvent	CDCI3						
4	Temperature	296.2						
5	Pulse Sequence	zgpg30						
6	Experiment	1D						
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)						
8	Number of Scans	368						
9	Receiver Gain	190.5						
1	0 Relaxation Delay	2.0000						
1	1 Pulse Width	10.0000						
1	2 Acquisition Time	1.0398						
1	3 Spectrometer Frequency	125.83						
1	4 Spectral Width	31512.6						
1	5 Lowest Frequency	-1898.2						
1	6 Nucleus	13C						
1	7 Acquired Size	32768						
1	8 Spectral Size	65536						
mana	Partakkoungelis, daragin spece onder an discription and gen	ſŇijĊŔŦſŧſĨŇŶŷĬĸŖŲŦijŇſſŢĨĠſſĿĿŀĬIJŊŶŊIJĬĸĸġħĸŶĹſĸĿſĿſĸŊŢĬŊſĹſĸĦŎĬĸĊŢĿIJĸIJĬŎĹſĸŶŔĸŔŊĿſŊĿIJŊŔŶĬ	YEL-UN THINK OF HIS SHOULD BE AND	ſŸŧţŧŶŊĴŧĸŢŖſŧġŊſĸijĄJĿĸſŢ <mark>Ĺ</mark> ĸĿĬŢĹĸŢĸ	njertidansk fyljalen i kansk fyljalen i ka	No dan sa lai prioda na ka uja vice proposa da na jari prio	Grease	Lange (Lange Manaka ng Kanga Kang
[							· · · · · · ·	

f1 (ppm)

Parameter	Value	DCI3		20 rease	L –
1 Origin	Varian	26 C		66 H 25 G	
2 Spectrometer	inova				Me
3 Solvent	CDCI3	I		1 1	
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	hcn				
8 Number of Scans	16				
9 Receiver Gain	30				
10 Relaxation Delay	0.0000				
11 Pulse Width	7.0000				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	500.07				
14 Spectral Width	8000.0				
15 Lowest Frequency	-1521.6				
16 Nucleus	1H	1			
17 Acquired Size	32768				
18 Spectral Size	65536				
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				,   i	
			<b>    </b>		

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value		CDCI3	L _
1 Origin	Bruker BioSpin GmbH		.16	
2 Spectrometer	spect		- 77	Me
3 Solvent	CDCI3		I	
4 Temperature	298.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	128			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	/ 125.83	1 1		
14 Spectral Width	31512.6			
15 Lowest Frequency	-1904.3			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
			4	
				I
<u>๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛</u>		. ]	๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛	

-1 f1 (ppm) Ó



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.0 7.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 8.5 7.0 6.5 6.0 1.0 f1 (ppm)



Parameter	Value	CI
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	$\checkmark$
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.1	
6 Pulse Sequence	zg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	16	
10 Receiver Gain	61.8	
11 Relaxation Delay	10.0000	
12 Pulse Width	12.0000	
13 Acquisition Time	3.2768	
14 Spectrometer Frequency	500.35	
15 Spectral Width	10000.0	
16 Lowest Frequency	-1759.2	
17 Nucleus	1H	
18 Acquired Size	32768	
19 Spectral Size	65536	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.2
6	Pulse Sequence	zgpg30
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	1024
1	0 Receiver Gain	190.5
1	1 Relaxation Delay	2.0000
1	2 Pulse Width	10.0000
1	3 Acquisition Time	1.0398
1	4 Spectrometer Frequency	/ 125.83
1	5 Spectral Width	31512.6
1	6 Lowest Frequency	-1879.9
1	7 Nucleus	13C
1	8 Acquired Size	32768
1	9 Spectral Size	65536
	_	

-1 f1 (ppm) 

		ę
Parameter	Value	
1 Origin	Varian	<u>ب</u> ر
2 Spectrometer	inova	L.
3 Solvent	CDCI3	
4 Temperature	20.0	
5 Pulse Sequence	s2pul	
6 Experiment	1D	
7 Probe	QUAD	
8 Number of Scans	16	
9 Receiver Gain	60	
10 Relaxation Delay	10.0000	
11 Pulse Width	6.5000	
12 Acquisition Time	4.6645	
13 Spectrometer Frequer	icy 499.69	
14 Spectral Width	7024.9	
15 Lowest Frequency	-1022.2	
16 Nucleus	1H	
17 Acquired Size	32768	
18 Spectral Size	65536	
		<u>н</u>
		,

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value			.H2Cl2	120	$\square$
1 Origin	Varian			0000	26 H	Ns
2 Spectrometer	inova	I	· · ·	ഗ	i I	
3 Solvent	CDCI3		1		I	
4 Temperature	20.0					
5 Pulse Sequence	s2pul					
6 Experiment	1D					
7 Probe	quadbp					
8 Number of Scans	8					
9 Receiver Gain	58					
10 Relaxation Delay	0.0000					
11 Pulse Width	5.8250					
12 Acquisition Time	4.0960					
13 Spectrometer Frequency	399.74					
14 Spectral Width	8000.0					
15 Lowest Frequency	-2427.9					
16 Nucleus	1H					
17 Acquired Size	32768	1 1				
18 Spectral Size	65536					
					Grease	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	DCI3		12 0	$\square$
1 Origin	Varian	.26 C		.54 H	Ns
2 Spectrometer	inova	~			
3 Solvent	CDCI3	I		'	
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	hcn				
8 Number of Scans	16			I	
9 Receiver Gain	60				
10 Relaxation Delay	0.0000				
11 Pulse Width	7.0000				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	500.07				
14 Spectral Width	8000.0				
15 Lowest Frequency	-1521.6				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
			л <b>д</b> 👗	ا البنية م	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	CDCI3
1 Origin	Varian	7.26
2 Spectrometer	inova	Î
3 Solvent	CDCI3	
4 Temperature	20.0	
5 Pulse Sequence	s2pul	
6 Experiment	1D	
7 Probe	hcn	
8 Number of Scans	16	I
9 Receiver Gain	42	1
10 Relaxation Delay	0.0000	
11 Pulse Width	7.0000	
12 Acquisition Time	4.0960	
13 Spectrometer Frequency	500.07	
14 Spectral Width	8000.0	
15 Lowest Frequency	-1521.4	
16 Nucleus	1H	
17 Acquired Size	32768	
18 Spectral Size	65536	
		بالمعمالي

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value		CDCI3	CH2Cl2	Н20	CI
1 Origin	Varian		- 56	30	.25	Ns
2 Spectrometer	inova	I	-	ц Ц	i I	
3 Solvent	CDCI3		I	I	I	
4 Temperature	20.0					
5 Pulse Sequence	s2pul					
6 Experiment	1D					
7 Probe	5mmsw					
8 Number of Scans	16		1			
9 Receiver Gain	60					
10 Relaxation Delay	0.0000					
11 Pulse Width	5.8250					
12 Acquisition Time	4.0960					
13 Spectrometer Frequency	399.74					
14 Spectral Width	8000.0					
15 Lowest Frequency	-2427.9					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					

.. 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value			CI
1 Origin	Bruker BioSpin GmbH	9 		N Ns
2 Spectrometer	spect	1		
3 Solvent	CDCI3			
4 Temperature	296.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1899.4			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
			1 .	
	1			
and many and an and	กุษแข่งสารรูปแหวรูปในหารีตอย่างที่สารราชสารแต่ของการออกการและที่สารรูปสารรูปสารรูประสุรุษรรูปในสารรูปสารรูประส สารรูปสารรูปแหวรูปในหารีตอย่างที่สารระดาศตาร์แต่งอย่างสารรูปสารรูปสารรูปสารรูปสารรูปสารรูปสารรูปสารรูปสารรูปสารร	หนู่ในสถานในทางการแหน่งการการส่วงสำนักที่สามาร์สามาร์สามาร์สามาร์สามาร์สามาร์สามาร์สามาร์สามาร์สามาร์	พายิจักรรณสารทางรุงรูปแบบสารทางการเหตุการเหตุ	 <sup>1</sup> ดการเป็นของเป็นไม่ที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่สุดที่ส

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												f1 (ppm)	)											400

Parameter	Value	DCI3		cetone	20	$\square$
1 Origin	Bruker BioSpin GmbH	26 C		L7 A	25 H	N Me Ns
2 Spectrometer	spect	- 7.5		-2.]	-1.1	
3 Solvent	CDCI3				Ι	
4 Temperature	296.1					
5 Pulse Sequence	zg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 50051	BBF-H-D-05 Z)				
8 Number of Scans	16					
9 Receiver Gain	190.5					
10 Relaxation Delay	10.0000					
11 Pulse Width	12.0000					
12 Acquisition Time	3.2768					
13 Spectrometer Frequence	y 500.35					
14 Spectral Width	10000.0					
15 Lowest Frequency	-1759.7					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
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		l		אווגואי	′ <b>N_I_</b>	

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value			<b>K</b>			cetone		$\sim$
1	Origin	Bruker BioSpin GmbH						9 A 9		N Me Ns
2	Spectrometer	spect			T.			31.0		
3	Solvent	CDCI3						Ĩ		
4	Temperature	296.1								
5	Pulse Sequence	zgpg30								
6	Experiment	1D								
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)								
8	Number of Scans	256								
9	Receiver Gain	190.5								
1	0 Relaxation Delay	2.0000		L						
1	1 Pulse Width	10.0000								
1	2 Acquisition Time	1.0398								
1	3 Spectrometer Frequency	125.83								
1	4 Spectral Width	31512.6								
1	5 Lowest Frequency	-1898.9								
1	6 Nucleus	13C								
1	7 Acquired Size	32768								
1	8 Spectral Size	65536								
									1	
					"					
مدريدا وزرار	ويسترجعها والمراجع والأكرير والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع	بالمؤمنية والمستعاد المعراب الموالية. ومؤلمته المعالية من المراجع والمراجع من المحالية ا	• الله ال	المتالياتين المتعريد أواليا المتعريد والمسارك والمتعادية والمتعادية والمتعارك والمتعارك والمتعادية والمتعادية	ula. Instations in	والمراجع المراجع والمراجع والمراجع والمراجع المراجع	أحداد فسرم وتأثبا فيلهاون خروا فالتراه		والمعالمة المراجعة والمعالمة والمتراجعة والمعالمة والمعالمة والمعالمة والمعالمة والمعالمة والمعالمة و	ر المن والد بالأرار الم المارية. معاد المعاد الذ الأرار المارية المارية المارية المارية المعاد الم
uvaliikhi)	n en	אינטאר אינטאר אינע אין אין אינער אין אין אינער אין אין אינער אין אין אינער אינער אינער אינער אינער אינער אינער אינער אינער אינ		a a men afaa maa si kacaa na dind inta dina ka ka ka mada ka ka ka ka di na di na ka ka ka Ka Ka Ka	del Antoini del	uuru waadadaa ahii hii hii hii hii hii hii hii hii	a ha hawa wa marafi na Artifi na fiyatika A	iairinal Nodi W	an de la company de la comp	ka tang navoniki ta wajaniki kalingingi a



5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2

	Parameter	Valu	e						cetone		$\frown$	
1	Origin	Bruker BioSpin GmbH				U U	0 0		Ý 6		N O	Ac
2	Spectrometer	spect							31.0			
3	Solvent	CDCI3							Ĩ			
4	Temperature	296.2										
5	Pulse Sequence	zgpg30										
6	Experiment	1D										
7	Probe	Z127784_0002 (CP BBO	500S1 BBF-H-D-0	)5 Z)								
8	Number of Scans	368			1							
9	Receiver Gain	190.5										
10	) Relaxation Delay	2.0000										
11	Pulse Width	10.0000										
12	2 Acquisition Time	1.0398										
13	3 Spectrometer Frequency	125.83										
14	Spectral Width	31512.6										
15	5 Lowest Frequency	-1898.7										
16	5 Nucleus	13C										
17	7 Acquired Size	32768										
18	3 Spectral Size	65536										
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hining	k den vir het efter seiten den ster seitet en den ster den ster den ster den ster den ster den ster ster ster s Er den vir het efter ster den ster ster ster ster ster ster ster ster	Hirmy (ny 1991) (Ny 1	n na hara da an hara da An hara da an	ivlaaliha Nikoperaatii perioo	ni vini (burninu nyaéhajin jipu hahana) (nji	UAUAR BANAY MANANANANA ANA ANA ANA ANA ANA ANA ANA	www.www.www.www.www.www.www.www.www.ww	alang ang ang ang ang ang ang ang ang ang	lanan lanan an	WinWWinWinWW	n ag na an	<b>Viimiini</b> i

-1 f1 (ppm) Ó

Parameter	١	/alue	CDCI3			H2O	CN CN
1 Origin	Bruker BioSpin GmbH		.26			.56	Ñs
2 Spectrometer	spect	I					
3 Solvent	CDCI3		•			,	
4 Temperature	296.1						
5 Pulse Sequence	zq30						
6 Experiment	1D						
7 Probe	Z127784_0002 (CP B	BO 500S1 BB	8F-H-D-05 Z)				
8 Number of Scans	16						
9 Receiver Gain	151.1	1					
10 Relaxation Delay	10.0000						
11 Pulse Width	12.0000						
12 Acquisition Time	3.2768						
13 Spectrometer Frequency	y 500.35						
14 Spectral Width	10000.0						
15 Lowest Frequency	-1760.2						
16 Nucleus	1H						
17 Acquired Size	32768						
18 Spectral Size	65536						
						1	
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.. 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value		
1	Origin	Rruker RioSpin CmbH		
2	Spectrometer	spect		
3	Solvent	CDCI3		
4	Temperature	296.1		
5	Pulse Sequence	zapa30		
6	Experiment	1D		I
7	Probe	Z127784 0002 (CP BBO 500S1 BBF-H-D-05 Z)		
8	Number of Scans	368		
9	Receiver Gain	190.5		
1(	0 Relaxation Delay	2.0000		
1	1 Pulse Width	10.0000		
12	2 Acquisition Time	1.0398		
13	3 Spectrometer Frequency	125.83		
14	4 Spectral Width	31512.6		
1	5 Lowest Frequency	-1900.3		
10	6 Nucleus	13C		
1	7 Acquired Size	32768		
18	8 Spectral Size	65536		
hillin (v	กษณะแหล่งให้ในที่มาเรื่องกับกระบบกระการการการสารที่ได้เรื่องได้เหตุได้เหตุได้เหตุได้เหตุได้เหตุได้เหตุได้เรื่อง เกมน์	ะสารแกรมสารแขนของการสารสารการการการการการสารสารสารสารสารสารสารสารสารสารสารสารสา	monely	udun


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Parameter	Value		<del>1901</del>	$\bigcirc$
1 Origin	Bruker BioSpin GmbH		9 <del>1</del>	1
2 Spectrometer	spect		n.	
3 Solvent	CDCI3			Ns
4 Temperature	296.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	256			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequen	ncy 125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1900.4			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
ŊſĨŇŊŶŶĬŶŴŊſĔŊŇŇŇĴĸŔŶĬſŦŊĬĬŔĿŴĬĬĬĬĬĬĬŎŎĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬĬ	นที่สุดที่การการการที่สุดสารที่แก่สารที่สุดสารที่สารที่สารที่สารที่สารที่สารที่สารที่สารที่สารที่สารที่สารที่สา	นกรุก III แต่ง เป็นหนึ่ง เป็นหนึ่ง เป็นหนึ่ง เป็นหนึ่ง เป็นหนึ่ง เป็นหนึ่ง เป็นหนึ่ง เป็นเป็นหนึ่ง เป็นเป็นเป็น	1 Lyon and margarety of the same war and the same with the second se	ๆ ๆ มูนั้นที่ทำให้เป็นหมายสามหนายากมีแห่งมีมีและการการการการการการการการการการการการการก

Parameter	Value					$\bigcirc$
1 Origin	Bruker BioSpin GmbH					N COOCH₃
2 Owner	user1d					0=\$=0
3 Instrument	spect					
4 Solvent	CDCI3					
5 Temperature	298.2					l COOCH₃
6 Pulse Sequence	zg30					
7 Experiment	1D					
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					
9 Number of Scans	16					
10 Receiver Gain	29.7					
11 Relaxation Delay	10.0000					
12 Pulse Width	12.0000		I	1		
13 Acquisition Time	3.2768					
14 Spectrometer Frequence	y 500.35					
15 Spectral Width	10000.0					
16 Lowest Frequency	-1921.8					
17 Nucleus	1H					
18 Acquired Size	32768					
19 Spectral Size	65536					
		1		1	A	
			M		M M M	
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2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	J
3 Instrument	spect	
4 Solvent	CDCI3	$\searrow$
5 Temperature	298.2	çoo
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	2048	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequer	ncy 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1901.8	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) 

Parameter	Value	OAc
1 Origin	Bruker BioSpin GmbH	N V Ns
2 Owner	user1d	
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.2	
6 Pulse Sequence	zg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	16	
10 Receiver Gain	86.0	
11 Relaxation Delay	10.0000	
12 Pulse Width	12.0000	
13 Acquisition Time	3.2768	
14 Spectrometer Frequence	y 500.35	
15 Spectral Width	10000.0	
16 Lowest Frequency	-1759.2	
17 Nucleus	1H	
18 Acquired Size	32768	
19 Spectral Size	65536	
	الـــــــالـــــــــــــــــــــــ	

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Parameter	Value	OAc
1 Origin	Bruker BioSpin GmbH	N Ns
2 Owner	user1d	
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.1	
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	1024	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequenc	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1874.7	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	
~~~~ <u>*~~</u> ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	┉┉┉┉┉╌╴╴┟┉┉┉┉┉╌╴╍┟┧╌┉╴╸╌┉┉╽┉╢┈╴┉┉╺╴┉┉┉┉┈┉┈┉┈┈╹└╴╴┈┉┟┈╸┉╢╴┈┉╴╸╢╴╢╢┉┈	

-1 f1 (ppm) Ó

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	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	298.1
6	Pulse Sequence	zg30
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	94.3
11	Relaxation Delay	10.0000
12	Pulse Width	12.0000
13	Acquisition Time	3.2768
14	Spectrometer Frequency	500.35
15	Spectral Width	10000.0
16	Lowest Frequency	-1921.8
17	Nucleus	1H
18	Acquired Size	32768
19	Spectral Size	65536

— 1.57 Н2О



LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value		F O N
1	Origin	Bruker BioSpin GmbH		$\sim$
2	Owner	user1d		
3	Instrument	spect		► N
4	Solvent	CDCI3		Ns
5	Temperature	298.2		
6	Pulse Sequence	zgpg30		
7	Experiment	1D		
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9	Number of Scans	256		
10	) Receiver Gain	190.5		
11	Relaxation Delay	2.0000		
12	2 Pulse Width	10.0000		
13	3 Acquisition Time	1.0398		
14	Spectrometer Frequency	125.83		
15	5 Spectral Width	31512.6		
16	5 Lowest Frequency	-1874.7		
17	7 Nucleus	13C		
18	3 Acquired Size	32768		
19	9 Spectral Size	65536		
				I
8.44°84,44	₩₽₽₽₽₩₽₩₽₩₽₽₩₩₽₽₩₩₽₽₩₽₽₽₩₽₽₩₽₽₩₽₽₽₩₽₽₽	www.www.www.www.www.www.della.ac.buww.www.wherewww.www.www.www.www.www.www.	ม <sup>ุ</sup> การการใหม่ไหวเหม <b>ุโ</b> การการการการที่ไหวการการการการการการการการการการการการการก	 

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.1
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072

Parameter	Value		Н20	Br 人
1 Origin	Bruker BioSpin GmbH	5.30	1.58	
2 Owner	user1d			
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	298.2			N L O
6 Pulse Sequence	zg30			0 <sup>=</sup> S
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			~
9 Number of Scans	16			
10 Receiver Gain	69.2			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequence	y 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1920.8			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value	Br
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	$\checkmark$
3	Instrument	spect	$\sim$
4	Solvent	CDCI3	
5	Temperature	298.2	
6	Pulse Sequence	zgpg30	o <sup>rs</sup>
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	· ·
9	Number of Scans	1024	
10	Receiver Gain	190.5	
11	Relaxation Delay	2.0000	
12	Pulse Width	10.0000	
13	Acquisition Time	1.0398	
14	Spectrometer Frequency	y 125.83	
15	Spectral Width	31512.6	
16	Lowest Frequency	-1875.2	
17	Nucleus	13C	
18	Acquired Size	32768	
19	Spectral Size	65536	
	- <del>·</del> · ·		

-1 f1 (ppm) 

Parameter	Value	Ns N	
1 Origin	Bruker BioSpin GmbH		)
2 Owner	user1d		
3 Instrument	spect		
4 Solvent	CDCI3		
5 Temperature	298.2		
6 Pulse Sequence	zg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	16		
10 Receiver Gain	86.0		
11 Relaxation Delay	10.0000		
12 Pulse Width	12.0000		
13 Acquisition Time	3.2768		
14 Spectrometer Frequenc	500.35		
15 Spectral Width	10000.0		
16 Lowest Frequency	-1922.3		
17 Nucleus	1H		
18 Acquired Size	32768		
19 Spectral Size	65536		

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value			Ns N
1 Origin	Bruker BioSpin GmbH	L		
2 Owner	user1d			
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	298.2			
6 Pulse Sequence	zgpg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	2048			
10 Receiver Gain	190.5			
11 Relaxation Delay	2.0000			
12 Pulse Width	10.0000			1
13 Acquisition Time	1.0398			
14 Spectrometer Frequenc	y 125.83			
15 Spectral Width	31512.6			
16 Lowest Frequency	-1874.5			
17 Nucleus	13C			
18 Acquired Size	32768			
19 Spectral Size	65536			
		1	/	

120 110 100 f1 (ppm) -10 150 140 130 

Parameter	Value	DCM	H2O	$\bigcirc$
1 Origin	Bruker BioSpin CmbH	5.30	1.55	N/N/
2 Owner	user1d	Ī	Î	Ns
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	296.2			
6 Pulse Sequence	za30			
7 Experiment	1D			
8 Probe	Z127784 0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	16		1	
10 Receiver Gain	151.1			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequenc	y 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1759.7			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			
	16 . /b /l			

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value	$\bigcirc$
1	Origin	Bruker BioSpin GmbH	N Ns
2	Owner	user1d	
3	Instrument	spect	
4	Solvent	CDCI3	
5	Temperature	296.2	
6	Pulse Sequence	zgpg30	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9	Number of Scans	1024	
10	Receiver Gain	190.5	
11	Relaxation Delay	2.0000	
12	Pulse Width	10.0000	
13	Acquisition Time	1.0398	
14	Spectrometer Frequency	y 125.83	
15	Spectral Width	31512.6	
16	<b>Lowest Frequency</b>	-1874.0	
17	' Nucleus	13C	
18	Acquired Size	32768	
19	Spectral Size	65536	

-1 f1 (ppm) Ó

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	Parameter	Value	
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	
3	Instrument	spect	
4	Solvent	CDCI3	
5	Temperature	298.2	
6	Pulse Sequence	zg30	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D	-D-05 Z)
9	Number of Scans	16	
10	Receiver Gain	122.8	
11	Relaxation Delay	10.0000	
12	Pulse Width	12.0000	
13	Acquisition Time	3.2768	
14	Spectrometer Frequency	500.35	
15	Spectral Width	10000.0	
16	Lowest Frequency	-1920.8	
17	Nucleus	1H	
18	Acquired Size	32768	
19	Spectral Size	65536	
		I	

Parameter	Value	H H
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	H Ns
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	298.2	
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	4096	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequence	/ 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1872.8	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) 

Parameter	Value	DCM	8 H20	Br
1 Origin	Bruker BioSpin GmbH	-5.30	1.55	
2 Owner	user1d			
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	298.2			
6 Pulse Sequence	zg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	16			
10 Receiver Gain	151.1			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequen	cy 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1920.8			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			

2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

NNs

Parameter	Value	Br
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	298.1	
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	2048	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequence	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1872.7	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) Ó

Parameter	Value	0 DC W		8 H2O	
1 Origin	Bruker BioSpin GmbH	Ω.		- 1.5	
2 Owner	user1d				
3 Instrument	spect				
4 Solvent	CDCI3				Ĭ
5 Temperature	298.1				
6 Pulse Sequence	zg30				
7 Experiment	1D				
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)				
9 Number of Scans	16				
10 Receiver Gain	69.2				
11 Relaxation Delay	1.0000		I		
12 Pulse Width	12.0000				
13 Acquisition Time	3.2768				
14 Spectrometer Frequency	y 500.35				
15 Spectral Width	10000.0				
16 Lowest Frequency	-1920.8				
17 Nucleus	1H				
18 Acquired Size	32768				
19 Spectral Size	65536				
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	II , Ali				
	/\/\/\/\/				

2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	COOMe 0 N II 0
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	
3 Instrument	spect	
4 Solvent	CDCI3	Ĭ Pr
5 Temperature	298.2	Di
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	512	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequence	cy 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1876.0	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

Parameter	Value				8 H2O	Br
1 Origin	Bruker BioSpin GmbH				- 1.5	
2 Owner	user1d					Br
3 Instrument	spect					
4 Solvent	CDCI3					
5 Temperature	296.2					
6 Pulse Sequence	zg30					
7 Experiment	1D					
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					
9 Number of Scans	16					
10 Receiver Gain	86.0					
11 Relaxation Delay	10.0000					
12 Pulse Width	12.0000					
13 Acquisition Time	3.2768					
14 Spectrometer Frequenc	y 500.35					
15 Spectral Width	10000.0					
16 Lowest Frequency	-1700.7					
17 Nucleus	1H					
18 Acquired Size	32768					
19 Spectral Size	65536	I				
			J	l l		

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value		Br
1	Origin	Bruker BioSpin GmbH		
2	Owner	user1d		Br
3	Instrument	spect		
4	Solvent	CDCI3		
5	Temperature	296.1		
6	Pulse Sequence	zgpg30		
7	Experiment	1D		
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9	Number of Scans	1024		
10	Receiver Gain	190.5		
11	Relaxation Delay	2.0000		
12	Pulse Width	10.0000		
13	Acquisition Time	1.0398		
14	Spectrometer Frequency	125.83		
15	Spectral Width	31512.6		
16	Lowest Frequency	-1874.8		
17	Nucleus	13C		
18	Acquired Size	32768		
19	Spectral Size	65536		
		1		1
	·		الــــــــــــــــــــــــــــــــــــ	-/il

-1 f1 (ppm) Ó

Parameter	Value				Ĵ.	_
1 Origin	Varian					L
2 Owner					$\rangle$	
3 Instrument	inova				/ Me	
4 Solvent	CDCI3					
5 Temperature	25.0					
6 Pulse Sequence	s2pul					
7 Experiment	1D					
8 Probe	hcn					
9 Number of Scans	16					
10 Receiver Gain	38					
11 Relaxation Delay	10.0000					
12 Pulse Width	7.0000					
13 Acquisition Time	4.0960					
14 Spectrometer Frequen	ncy 500.07					
15 Spectral Width	8000.0					
16 Lowest Frequency	-1520.6					
17 Nucleus	1H				1	
18 Acquired Size	32768					
19 Spectral Size	65536					
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			A	الأمامين والأسل		

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value		CI
1 Origin	Bruker BioSpin GmbH		N
2 Owner	user1d		$\neg$
3 Instrument	spect		Me
4 Solvent	CDCI3		
5 Temperature	298.2		
6 Pulse Sequence	zgpg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	512		
10 Receiver Gain	190.5		
11 Relaxation Delay	2.0000		
12 Pulse Width	10.0000		
13 Acquisition Time	1.0398		
14 Spectrometer Frequency	125.83		
15 Spectral Width	31512.6		
16 Lowest Frequency	-1898.4		
17 Nucleus	13C		
18 Acquired Size	32768		
19 Spectral Size	65536		

-1 f1 (ppm) Ó

Parameter	Value			CI
1 Origin	Bruker BioSpin GmbH			N
2 Owner	user1d			Me
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	296.2			
6 Pulse Sequence	zg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BE	-H-D-05 Z)		
9 Number of Scans	16			
10 Receiver Gain	190.5			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768		1	
14 Spectrometer Frequence	y 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1759.7			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			
		1		
			ا الشغفة ا	

.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value			O CI
1 Origin	Bruker BioSpin GmbH			N N
2 Owner	user1d			Me
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	296.1			
6 Pulse Sequence	zgpg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	1024			
10 Receiver Gain	190.5			
11 Relaxation Delay	2.0000			
12 Pulse Width	10.0000			
13 Acquisition Time	1.0398			
14 Spectrometer Frequer	cy 125.83			
15 Spectral Width	31512.6			
16 Lowest Frequency	-1873.7			
17 Nucleus	13C			
18 Acquired Size	32768			
19 Spectral Size	65536			
njarnalinanyhnyknyknyknyknykjyljichyknyknyknyknyknyknyknyknyknyknyknyknykny	มหนุมสถ <sub>า</sub> นการสนใหญ่ประการมีนการการที่สามหารกา <i>สสมส</i> นสาหารการการการการการสนให้สามารถมาให้สารการการที่	พงต <sup>ิ</sup> โรงสามมิสมุณข้านไว้ได้สามหนึ่งหมาไปม้การกับให้แห่งการกับให้แห่งสามมินสามมิสมให้สามหาไม่มีการการสามการ	d pallanananananananananananan mananananananan	ะงจะเกมเป็นไปการการแหน่ไหนใหม่ในเหมาะจายเกรียนแหน่งเกมาเหมาะการการการการการการการการการการการการการก

-1 f1 (ppm) Ó 



0.0 -0.5 -1.0 -1.5 -2 172 .0 11.5 11.0 10.5 10.0 9.5 7.5 1.5 1.0 9.0 8.5 8.0 7.0 5.5 5.0 4.5 3.5 3.0 2.5 2.0 6.5 6.0 4.0 0.5 f1 (ppm)



5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0

Parameter	Value		CDCI3				
1 Origin	Varian		7.26				IVIE
2 Spectrometer	inova						
3 Solvent	CDCI3						
4 Temperature	20.0						
5 Pulse Sequence	s2pul						
6 Experiment	1D						
7 Probe	quadbp						
8 Number of Scans	16						
9 Receiver Gain	48						
10 Relaxation Delay	0.0000						
11 Pulse Width	5.8250						
12 Acquisition Time	4.0960						
13 Spectrometer Frequency	399.74						
14 Spectral Width	8000.0						
15 Lowest Frequency	-2426.7						
16 Nucleus	1H	I					
17 Acquired Size	32768						
18 Spectral Size	65536						
				1			

1.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2.0 f1 (ppm)

	Parameter	Value		CDCI3			$\sum_{N}$
1 Or	rigin	Bruker BioSpin GmbH		.16 0			Me Ns
2 Sp	ectrometer	spect		- 77			
3 So	lvent	CDCI3		1			
4 Te	emperature	298.2					
5 Pu	lse Sequence	zgpg30					
6 Ex	periment	1D					
7 Pro	obe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					
8 Νι	umber of Scans	256					
9 Re	eceiver Gain	190.5					
10 Re	elaxation Delay	2.0000					
11 Pu	llse Width	10.0000					
12 Ac	quisition Time	1.0398					
13 Sp	ectrometer Frequency	125.83	I				
14 Sp	ectral Width	31512.6					
15 Lo	west Frequency	-1902.4					
16 Nı	ucleus	13C					
17 Ac	quired Size	32768					
18 Sp	ectral Size	65536					
					I		
		I					
				J			

-1 f1 (ppm) Ó

Parameter	Value		CDCI3				Ment
1 Origin	Varian		7.26				NIC N
2 Spectrometer	inova						
3 Solvent	CDCI3						
4 Temperature	20.0						
5 Pulse Sequence	s2pul						
6 Experiment	1D						
7 Probe	quadbp						
8 Number of Scans	16						
9 Receiver Gain	58						
10 Relaxation Delay	10.0000						
11 Pulse Width	5.8250						
12 Acquisition Time	4.0960						
13 Spectrometer Frequency	399.74						
14 Spectral Width	8000.0						
15 Lowest Frequency	-2426.7						
16 Nucleus	1H						
17 Acquired Size	32768						
18 Spectral Size	65536						
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		1					
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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

		'   '		'	'	'	'	'	'	'	'	'	'	'	'   '				'	'   '	1 1	1 1		· ·
30	220	210	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	-1
												f1 (ppm)	)											

Paramotor	Value	LCI3		50	ſ
rarameter	value	10 92		99 9	Me
1 Origin	Varian	- 7.2			
2 Spectrometer	inova	I			
3 Solvent	CDCI3				
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	quadbp				
8 Number of Scans	16				
9 Receiver Gain	58				
10 Relaxation Delay	10.0000				
11 Pulse Width	5.8250				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	399.74				
14 Spectral Width	8000.0				
15 Lowest Frequency	-2427.9				
16 Nucleus	1H			!	
17 Acquired Size	32768				
18 Spectral Size	65536				
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			Λ	/	
		J			

L.O 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value					<del>1</del> <del>3</del>			Me
1 (	Drigin	Bruker BioSpin GmbH								NS
2 5	Spectrometer	spect				i	r.			
3 5	olvent	CDCI3								
4 7	Femperature	298.2								
5 F	Pulse Sequence	zgpg30								
6 E	Experiment	1D								
7 F	Probe	Z127784_0002 (CP BBO 500S1 BB	F-H-	D-05 Z)						
8 N	Number of Scans	256								
9 F	Receiver Gain	190.5								
10 F	Relaxation Delay	2.0000								
11 F	Pulse Width	10.0000								
12 A	Acquisition Time	1.0398								
13 S	Spectrometer Frequency	125.83								
14 S	Spectral Width	31512.6								
15 L	owest Frequency	-1898.4								
16 M	Nucleus	13C								
17 A	Acquired Size	32768			ĺ			1		
18 S	Spectral Size	65536								
			1							
							,"			1
()w <b>ilet</b> (tw	(hlimiliainnainna hallan in an	navnyhvytwoantoviterheytettetetetettettettettettettettettette	mmm	analanan un analanan analanan a	huliuuv	๚๚๚๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛	/ waterninetimentaniarwaw	ฟ <sup>ู</sup> เสียงกับโรงๆไปข่ามอุกังที่หนึ่งไปสัตวรับสุดขณะไปเหมืองไปทาง	hadannaarad	Manadalan ang ang ang ang ang ang ang ang ang a

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5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2


5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2





Parameter	Value	<del></del>	CI
1 Origin	Bruker BioSpin GmbH	<del>9</del>	Me''' N/
2 Spectrometer	spect	h.	
3 Solvent	CDCI3		
4 Temperature	298.1		
5 Pulse Sequence	zgpg30		Me N
6 Experiment	1D		(minor)
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
8 Number of Scans	368		
9 Receiver Gain	190.5		
10 Relaxation Delay	2.0000		
11 Pulse Width	10.0000		
12 Acquisition Time	1.0398		
13 Spectrometer Frequency	125.83		
14 Spectral Width	31512.6		
15 Lowest Frequency	-1916.9		
16 Nucleus	13C		
17 Acquired Size	32768		
18 Spectral Size	65536		
8#44444481478104904949494444444444444444444444444444			35

Parameter	Value		CDCI3		Сооме
1 Origin	Varian		7.26		Me <sup>-</sup> Ns
2 Spectrometer	inova				+
3 Solvent	CDCI3				
4 Temperature	20.0				COOMe N
5 Pulse Sequence	s2pul				Me Ns
6 Experiment	1D				(minor)
7 Probe	hcn				
8 Number of Scans	16				
9 Receiver Gain	32				
10 Relaxation Delay	10.0000				
11 Pulse Width	7.0000				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	500.07				
14 Spectral Width	8000.0				
15 Lowest Frequency	-1521.4				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter 1 Origin	Value Varian			7.16 CDCl3		Me <sup>''''</sup> Ns
2 Spectrometer	inova					+
3 Solvent	CDCI3					
4 Temperature	20.0					Menn
5 Pulse Sequence	s2pul					NS (residented)
6 Experiment	1D					(minor)
7 Probe	QUAD					
8 Number of Scans	160					
9 Receiver Gain	60					
10 Relaxation Delay	2.0000					
11 Pulse Width	6.0000					
12 Acquisition Time	1.0863		. 1			
13 Spectrometer Frequency	125.66					
14 Spectral Width	30165.9					
15 Lowest Frequency	-1277.1					
16 Nucleus	13C					
17 Acquired Size	32768					
18 Spectral Size	65536					
						1
					1	
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ualihuluwikalihudhikalihalihalihalihalihalihalihalihalihalih	nn han an a	ni an ina ang ing ang ang ang ang ang ang ang ang ang a	L PARAN LANDAL AN DANA MANANA MANA	is niku kinakisi na dalami nda kikan dala na dani dala dala dala dala dala dala dala dal	Indiatal And Montanta Indiates (1704)	v o hait na bana ka ka fi daha ka

Parameter	Value		CDCI3		
1 Origin	Varian		.26 0		
2 Spectrometer	inova		~		
3 Solvent	CDCl3		I		
4 Temperature	20.0				
5 Pulse Sequence	s2nul				
6 Experiment	1D				
7 Probe	quadbp				
8 Number of Scans	16				
9 Receiver Cain	48				
10 Relayation Delay	10 0000				
11 Dulco Width	5 8250				
12 Acquisition Time	1 0060				
13 Spectrometer Freque	+.0500				
14 Spectral Width	8000 0				
15 Lowest Frequency	0000.0 7 7 7 CACO				
15 Lowest Frequency	-2427.7				
16 Nucleus	18				
17 Acquired Size	32768				
18 Spectral Size	65536				
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.. 0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value		CDCI3				Ĺ
1 Origin	Varian		7.26			1	/le``
2 Spectrometer	inova		Î				
3 Solvent	CDCI3						
4 Temperature	20.0						
5 Pulse Sequence	s2pul						
6 Experiment	1D						
7 Probe	hcn						
8 Number of Scans	16						
9 Receiver Gain	36						
10 Relaxation Delay	10.0000						
11 Pulse Width	7.0000						
12 Acquisition Time	4.0960						
13 Spectrometer Frequency	500.06						
14 Spectral Width	8000.0						
15 Lowest Frequency	-1513.1						
16 Nucleus	1H						
17 Acquired Size	32768						
18 Spectral Size	65536						
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		I I					
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... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	CDCl3		$\sim$
1 Origin	Bruker BioSpin GmbH	.16		Me <sup>N</sup> N Me
2 Spectrometer	spect	- 77		
3 Solvent	CDCI3	I		
4 Temperature	298.2			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	/ 125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1916.9			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
1				
	1			
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-1 f1 (ppm) Ó







5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0

Parameter	Value			Crease
1 Origin	Bruker BioSpin GmbH			Ke Ne Ne
2 Spectrometer	spect		7:	- 29
3 Solvent	CDCI3			I
4 Temperature	298.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1898.5			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
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30 220 210 200		130 120 110 100 90	80 70 60 50 40	







Parameter	Value	CDCI3	
1 Origin	Bruker BioSpin GmbH	2.16	Me <sup>rr</sup> N OAc Ns
2 Spectrometer	spect	7	+
3 Solvent	CDCI3		
4 Temperature	298.1		
5 Pulse Sequence	zgpg30		Me N OAc
6 Experiment	1D		(minor)
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
8 Number of Scans	368		
9 Receiver Gain	190.5		
10 Relaxation Delay	2.0000		
11 Pulse Width	10.0000		
12 Acquisition Time	1.0398		
13 Spectrometer Frequency	125.83		
14 Spectral Width	31512.6		
15 Lowest Frequency	-1900.6		
16 Nucleus	13C		
17 Acquired Size	32768		
18 Spectral Size	65536		

-1 f1 (ppm) 



2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2. f1 (ppm)

Parameter	Value								
1 Origin	Varian								115
2 Spectrometer	inova			,					
3 Solvent	CDCI3								
4 Temperature	0.0								
5 Pulse Sequence	s2pul								
6 Experiment	1D								
7 Probe	QUAD								
8 Number of Scans	208								
9 Receiver Gain	60								
10 Relaxation Delay	2.0000								
11 Pulse Width	6.0000								
12 Acquisition Time	1.0863								
13 Spectrometer Frequency	125.66								
14 Spectral Width	30165.9								
15 Lowest Frequency	-1260.2								
16 Nucleus	13C								
17 Acquired Size	32768								
18 Spectral Size	65536								
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n di kana kana kana kana kana kana kana kan	i de la company de la comp	أالاب أرأب انظيناتها الإزاتيل الكاريبا إياب	i Mini	المالية المتحدين وفراتها بالأبلاط فيعاطه والشويريان ووالتهاز ومرواض الفاص وبالابهو					
ուս ու աներությունը հայտարերը ու արդանությունը ու արդաները։ Դեն հետ հայտարերը հայտ	, ג. גער איז	and a state of a second se	41.464	an an na an a	ու հովհայրերի անձաներ		այն հերհեն տեղեն, որ I շ.	ار مال ورائظهر ۲۱۱ داره ۲۱۱ بلند – او ماله ا	իչչակը լույցություն՝ կորերինու լություն։ Դուրին հետություն է հետոներին հետություն։

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.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0 f1 (ppm)

Parameter Value g
Origin Bruker BioSpin GmbH
Spectrometer spect
Solvent CDCl3
Temperature 296.1
Pulse Sequence zapa30
Experiment 1D
Probe Z127784 0002 (CP BBO 500S1 BBF-H-D-05 Z)
Number of Scans 368
Receiver Gain 190.5
Relaxation Delay 2.0000
Pulse Width 10.0000
Acquisition Time 1.0398
Spectrometer Frequency 125.83
Spectral Width 31512.6
Lowest Frequency –1916.9
Nucleus 13C
Acquired Size 32768
Spectral Size 65536
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Parameter	Value	H2O grease	$\bigcap$
1 Origin	Bruker BioSpin GmbH	.25	
2 Owner	user1d		o=s=o
3 Instrument	spect		
4 Solvent	CDCI3		
5 Temperature	298.2		Ý
6 Pulse Sequence	zg30		COOCH <sub>3</sub>
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	16		
10 Receiver Gain	61.8		
11 Relaxation Delay	10.0000		
12 Pulse Width	12.0000		
13 Acquisition Time	3.2768		
14 Spectrometer Frequer	ncy 500.35		
15 Spectral Width	10000.0		
16 Lowest Frequency	-1920.3		
17 Nucleus	1H		
18 Acquired Size	32768		
19 Spectral Size	65536		
		1	

11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

-1 f1 (ppm) ò

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Parameter 1 Origin 2 Ourper	Value Varian		– 7.26 CDCl3				O=S=0
2 Owner	inova		I				
3 Instrument	Inova CDCI3						
5 Tomporaturo	20.0						COOCH3
6 Pulse Sequence	20.0 s2pul						
7 Experiment	32pui 1D						
8 Probe							
9 Number of Scans	16						
10 Receiver Cain	60						
11 Relaxation Delay	6.0000						
12 Pulse Width	6.5000						
13 Acquisition Time	4.6645						
14 Spectrometer Frequer	icy 499.69						
15 Spectral Width	7024.9				1		
16 Lowest Frequency	-1021.9						
17 Nucleus	1H						
18 Acquired Size	32768						
19 Spectral Size	65536						
		1					
		1					
						1	
			1				
						M	
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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	298.2
6	Pulse Sequence	zg30
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	94.3
11	Relaxation Delay	10.0000
12	Pulse Width	12.0000
13	Acquisition Time	3.2768
14	Spectrometer Frequency	500.35
15	Spectral Width	10000.0
16	Lowest Frequency	-1922.3
17	Nucleus	1H
18	Acquired Size	32768
19	Spectral Size	65536

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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 fl (ppm)

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Parameter	Value		OAc
1 Origin	Bruker BioSpin GmbH		Me <sup>v</sup> N • Ns
2 Owner	user1d		
3 Instrument	spect	1	
4 Solvent	CDCI3		
5 Temperature	298.2		
6 Pulse Sequence	zgpg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	1024		
10 Receiver Gain	190.5		
11 Relaxation Delay	2.0000		
12 Pulse Width	10.0000		
13 Acquisition Time	1.0398		
14 Spectrometer Frequency	125.83		
15 Spectral Width	31512.6		
16 Lowest Frequency	-1898.7		
17 Nucleus	13C		
18 Acquired Size	32768		
19 Spectral Size	65536		







.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 1.0 f1 (ppm)

Parameter	Value			e Crease
1 Origin	Bruker BioSpin GmbH		1	
2 Spectrometer	spect		۲.	
3 Solvent	CDCI3			
4 Temperature	296.2			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	1280			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6	I		
15 Lowest Frequency	-1899.0			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size				
				Landon nuk kataa unta dina di nukad parbatan kata da

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Spectrometer	spect
3	Solvent	CDCI3
4	Temperature	296.2
5	Pulse Sequence	zgflqn
6	Experiment	1D
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
8	Number of Scans	16
9	Receiver Gain	190.5
10	Relaxation Delay	2.0000
11	Pulse Width	15.0000
12	Acquisition Time	0.5767
13	Spectrometer Frequency	470.75
14	Spectral Width	113636.4
15	Lowest Frequency	-103898.1
16	Nucleus	19F
17	Acquired Size	65536
18	Spectral Size	131072



Parameter	Value	0 DCM				Br
1 Origin	Bruker BioSpin GmbH	5.3				
2 Owner	user1d					$\mathbf{i}$
3 Instrument	spect					$\mathbf{k}$
4 Solvent	CDCI3					
5 Temperature	298.2					N Me
6 Pulse Sequence	zg30					0 <sup>=S</sup>
7 Experiment	1D					Ľ
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					~
9 Number of Scans	2					
10 Receiver Gain	69.2					
11 Relaxation Delay	1.0000					
12 Pulse Width	12.0000					
13 Acquisition Time	3.2768					
14 Spectrometer Frequency	500.35					
15 Spectral Width	10000.0					
16 Lowest Frequency	-1920.8			1		
17 Nucleus	1H					
18 Acquired Size	32768					
19 Spectral Size	65536					
					~ .	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)
Parameter	Value			Br
1 Origin	Bruker BioSpin GmbH			
2 Owner	user1d			$\checkmark$
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	298.1			N <sup>2</sup> Me I <sub>2</sub> O
6 Pulse Sequence	zgpg30			0 <sup>=</sup> <sup>S</sup>
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z	)		~
9 Number of Scans	128		1	
10 Receiver Gain	190.5			
11 Relaxation Delay	2.0000			
12 Pulse Width	10.0000			
13 Acquisition Time	1.0398			
14 Spectrometer Frequer	cy 125.83			
15 Spectral Width	31512.6			
16 Lowest Frequency	-1875.6			
17 Nucleus	13C			
18 Acquired Size	32768			
19 Spectral Size	65536			

-1 f1 (ppm) Ó







Parameter	Value	DCM	' Ether	Н20	NNs
1 Origin	Bruker BioSpin GmbH	5.30	2.17	1.55	
2 Owner	user1d				Me
3 Instrument	spect				
4 Solvent	CDCI3				
5 Temperature	296.1				
6 Pulse Sequence	zg30				
7 Experiment	1D				
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)				
9 Number of Scans	16				
10 Receiver Gain	168.2				
11 Relaxation Delay	10.0000				
12 Pulse Width	12.0000				
13 Acquisition Time	3.2768				
14 Spectrometer Frequency	y 500.35				
15 Spectral Width	10000.0				
16 Lowest Frequency	-1760.2				
17 Nucleus	1H				
18 Acquired Size	32768				
19 Spectral Size	65536				
				M	

1       Orkipin       Bruker BioSpin CmbH       userLd         2       Owner       userLd         3       Instrument       Spect         4       Solvent       ODCI3         5       Temperature       26.1         6       Pulse Sequence       2gpg30         7       Experiment       10         8       Probe       2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)         9       Number of Stams       1024         10       Receiver Gatin       10.000         12       Relax Width       10.000         13       Acquistion Delay       2.0000         13       Acquistion Stata       10.308         14       Bectormeter Frequency       12.583         15       Spectral Width       31512.6         16       Lowest Frequency       -1873.6         17       Macleus       132768         19       Spectral Width       3151.2         19       Spectral Width       3151.2         19       Spectral Width       3151.4         19       Spectral Width       3151.4         19       Spectral Width       Spectral Width         10       Spectral Width <th></th> <th>Parameter</th> <th>Value</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th><math>\bigcap</math></th> <th>\ NNs</th>		Parameter	Value								$\bigcap$	\ NNs
2         Owner         user1d         spect           3         Instrument         spect           4         Solvent         CCD3           5         Temperature         296.1           6         Pube Sequence         zggg30           7         Experiment         10           8         Probe         2127784_0002 (CP BBO 50051 BBT-H-D-05 Z)           9         Number of Scans         1024           10         Recover Gain         10.0000           11         Relaxation Delay         2.0000           12         Pube Width         10.0000           13         Acquistition Time         10.0398           14         Spectrare Width         31512.6           16         Lowest Frequency         1873.6           17         Nucless I Paguersy         1376.3           18         Acquired Size         32768           19         Spectral Size         65536	1	Origin	Bruker BioSpin GmbH									$\langle$
3       Instrument       Spect         4       Solvent       CDC3         5       Temperative       Spect-         6       Multe Sequence       Speg30         7       Experiment       10         8       Prote       C127784_0002 (CP BBD 50051 BBF-H-D-05 Z)         9       Number of Scans       102         10       Reciver Gain       3005         11       Relaxion Delay       20000         12       Hoto       10.0000         13       Acquistion Delay       25.83         14       Spectral Width       31512.6         15       Lowest Frequency       127.83         16       Lowest Frequency       127.83         17       Noclus       32.76         18       Acquired Size       32.76         19       Spectral Width       35.56	2	Owner	user1d									Me
4       Solvent       CDC3         5       Temperature       296.1         6       Pubs Segues       Soppilo         7       Experiment       10         8       Tomber of Scans       2127784_0002 (CP BBO S0051 BBF-H-D-OS Z)         9       Number of Scans       2127784_0002 (CP BBO S0051 BBF-H-D-OS Z)         9       Number of Scans       2127784_0002 (CP BBO S0051 BBF-H-D-OS Z)         10       Receiver Gain       10.5         11       Relaxiton       2000         12       Relaxiton       2000         13       Adjustion Time       10.398         14       SeperativeFrequenty       25.83         15       SeperativeFrequenty       25.83         17       Nacleus       23768         18       Acquired Size       23768         19       SeperativeFrequenty       25.36	3	Instrument	spect									
5       Temperature       296.1         6       Pulse Sequence       2pg30         7       Experime       10         8       Porbe       212784_0002 (CP BB0 50051 BBF-H-D-05 2)         9       Number of Sam       00-5         10       Receiver Gain       00-5         11       Relaxiton Delay       2000         12       Pulse Width       0.0000         13       Acquisiton Time       1.0398         14       Sectormeter Frequency       125.83         15       Sectormeter Frequency       137.6         17       Nucleus       132         18       Acquisiton Time       132.6         19       Sectoral Size       5356	4	Solvent	CDCI3									
6         Pulse Sequence         zpsg30           7         Experiment         10           8         Probe         2127784_0002 (CP BB0 50051 BBF-H-D-05 2)           9         Number of Scans         1024           10         Receiver Gain         10.5           11         Relaxion Data         20000           12         Pulse Width         0.0000           13         Relaxion Time         0.338           14         Spectrometrometrometrometrometrometrometrome	5	Temperature	296.1									
7       Experiment       10         8       Polo       2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)         9       Number of Scan       1024         10       Beceiver Gain       10.5         11       Relaxation Delay       2.000         12       Pulse With       10.000         13       Acquisition Time       1.0398         14       Spectral With       1512.6         15       Spectral With       1512.6         16       Korey Frequency       12768         17       Nucles       12768         19       Spectral Size       12536	6	Pulse Sequence	zgpg30									
8         Probe         127784_0002 (CP BB0 50051 BBF-H-D-052)           9         Number of Cam         120           10         Recker Cam         30-5           11         Relaxation Delay         2.000           12         Paloe Math         0.000           13         Aquifor Math         0.000           14         Pactromet Frequence         12.53           15         Spectral With         3.512.6           16         Lowes Frequence         127.6           17         Nucleo         3.76           18         Acquired Size         327.6           19         Spectral Size         55.36	7	Experiment	1D									
9         Number of Scans         102           10         Reciver Gain         1905           11         Relaxion Hinto         0.000           12         Pulse Width         0.303           13         Acquisition Time         0.398           14         Spectral Width         3151.26           15         Spectral Vidth         3152.26           16         Lowest Frequency         1873.6           17         Nucleus         32768           18         Acquired Size         5536	8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)									
10       Reciver Cain       190.5         11       Relaxation Delay       2.000         12       Pulse With       10.0000         13       Acquisition Time       10.398         14       Spectrometer Frequery       125.3         15       Spectrometer Frequery       131.26         16       Lowes Frequery       137.36         17       Nucleus       132.76         18       Acquired Size       32768         19       Spectral Size       6536	9	Number of Scans	1024									
11       Relaxation Delay       2.0000         12       Pude Width       10.000         13       Acquisition Time       1.0398         14       Spectrometer Frequency       125.83         15       Spectral Width       152.6         16       Lowst Frequency       -1873.6         17       Nucleus       13.C         18       Acquired Size       2268         19       Spectral Size       6556	10	Receiver Gain	190.5									
12       Pulse Width       10.000         13       Acquisition Time       1.038         14       Spectrometer Frequery       1512.6         15       Spectral Width       1512.6         16       Lowest Frequery       1873.6         17       Nucleus       132         18       Acquired Size       12768         19       Spectral Size       5536	11	Relaxation Delay	2.0000									
13       Acquisition Time       1.0398         14       Spectrometer Frequency       125.8         15       Spectral Widh       31512.6         16       Lowest Frequency       1.873.6         17       Nucleus       13C         18       Acquired Size       32768         19       Spectral Size       6536	12	Pulse Width	10.0000									
14       Spectrometer Frequency       125.83         15       Spectral Width       3151.6         16       Lowest Frequency       -1873.6         17       Nucleo       32768         18       Acquired Size       65536	13	Acquisition Time	1.0398									
15 Spectral Width       31512.6         16 Lowest Frequency       -1873.6         17 Nucleus       13C         18 Acquired Size       32768         19 Spectral Size       6536	14	Spectrometer Frequency	125.83									
16 Lowest Frequency       -1873.6         17 Nucleus       13C         18 Acquired Size       32768         19 Spectral Size       65336	15	Spectral Width	31512.6									
17 Nucleus       13C         18 Acquired Size       32768         19 Spectral Size       65536	16	Lowest Frequency	-1873.6									
18 Acquired Size       32768         19 Spectral Size       65536	17	Nucleus	13C									
19 Spectral Size 65536	18	Acquired Size	32768									
	19	Spectral Size	65536									
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										1		
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Parameter	Value	DCM	grease	$\bigcirc$
1 Origin	Bruker BioSpin GmbH	.30		∖ <mark>N</mark> ∕∕ Me
2 Owner	user1d			Ns
3 Instrument	spect	, , , , , , , , , , , , , , , , , , ,	'	
4 Solvent	CDCI3			
5 Temperature	296.2			
6 Pulse Sequence	zg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-	)5 Z)		
9 Number of Scans	16			
10 Receiver Gain	137.4			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequency	/ 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1923.3			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			

	Parameter	Value			$\bigcirc$
1	Origin	Bruker BioSpin GmbH			N Me
2	Owner	user1d			115
3	Instrument	spect			
4	Solvent	CDCI3			
5	Temperature	296.2			
6	Pulse Sequence	zgpg30			
7	Experiment	1D			
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9	Number of Scans	512			
10	Receiver Gain	190.5			
11	Relaxation Delay	2.0000			
12	Pulse Width	10.0000			
13	Acquisition Time	1.0398			
14	Spectrometer Frequency	125.83			
15	Spectral Width	31512.6			
16	Lowest Frequency	-1886.7			
17	Nucleus	13C			
18	Acquired Size	32768			
19	Spectral Size	65536			
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Parameter	Value
Origin	Bruker BioSpin GmbH
Owner	user1d
Instrument	spect
Solvent	CDCI3
Temperature	298.1
Pulse Sequence	zg30
Experiment	1D
Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
Number of Scans	16
Receiver Gain	69.2
Relaxation Delay	10.0000
Pulse Width	12.0000
Acquisition Time	3.2768
Spectrometer Frequency	500.35
Spectral Width	10000.0
Lowest Frequency	-1922.5
Nucleus	1H
Acquired Size	32768
Spectral Size	65536
	Parameter Origin Owner Instrument Solvent Temperature Pulse Sequence Experiment Pulse Sequence Sequence Number of Scans Receiver Gain Relaxation Delay Relaxation Delay Pulse Width Acquisition Time Spectrometer Frequency Spectral Width Lowest Frequency Nucleus Acquired Size



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	Parameter	Value		H
1	Origin	Bruker BioSpin GmbH		N, Me
2	Owner	user1d		H Ns
3	Instrument	spect		
4	Solvent	CDCI3		
5	Temperature	298.1		
6	Pulse Sequence	zgpg30		
7	Experiment	1D		
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9	Number of Scans	256		
10	Receiver Gain	190.5		
11	Relaxation Delay	2.0000		
12	Pulse Width	10.0000		
13	Acquisition Time	1.0398		
14	Spectrometer Frequency	125.83		
15	Spectral Width	31512.6		
16	Lowest Frequency	-1874.6		
17	Nucleus	13C		
18	Acquired Size	32768		
19	Spectral Size	65536		
		I		
**	ปลงการๆไส่งระหา <sub>ว</sub> ออาเพราะการๆกันประติประทุณภาษังชาวอีงๆ <sub>ไ</sub> ประเทศนี้ได้		 ┖╌┈╼┍╴╌╌┝╴┖┍╍╌╌┥┟╌╴╌╴┠╖║┟┧╢║╌╌╌╴║╌╸	าร์กระจะสามารถสารใหญาแห่งรูปสามารถเป็นเหตุสามารถหาย

-1 f1 (ppm) Ó







1.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 7.0 6.0 1.0 f1 (ppm)

Parameter	Value	Br	
1 Origin	Bruker BioSpin GmbH		Ĭ
2 Owner	user1d		Me
3 Instrument	spect		
4 Solvent	CDCI3		
5 Temperature	298.2		
6 Pulse Sequence	zgpg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	512		
10 Receiver Gain	190.5		
11 Relaxation Delay	2.0000		
12 Pulse Width	10.0000		
13 Acquisition Time	1.0398		
14 Spectrometer Frequen	y 125.83		
15 Spectral Width	31512.6		
16 Lowest Frequency	-1874.5		
17 Nucleus	13C		
18 Acquired Size	32768		
19 Spectral Size	65536		

Parameter	Value	CDCI3			H2O	
1 Origin	Bruker BioSpin GmbH	7.26			1.56	
2 Owner	user1d					Me
3 Instrument	spect					
4 Solvent	CDCI3					$\sim$
5 Temperature	296.1					Br
6 Pulse Sequence	zg30					
7 Experiment	1D					
8 Probe	Z127784_0002 (CP BBO 500S1	BBF-H-D-05 Z)				
9 Number of Scans	16					
10 Receiver Gain	137.4			1		
11 Relaxation Delay	10.0000					
12 Pulse Width	12.0000					
13 Acquisition Time	3.2768					
14 Spectrometer Frequence	zy 500.35					
15 Spectral Width	10000.0					
16 Lowest Frequency	-1922.3					
17 Nucleus	1H					
18 Acquired Size	32768					
19 Spectral Size	65536					
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		1				
	1.1					
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			11			
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Parameter	Value	COOMe O N U O
1 Origin		
2 Owner	userid	
3 Instrument	spect	
		l Br
5 Temperature	296.1	
6 Puise Sequence	2gpg30	
2 Broke		
o Probe	2127784_0002 (CP BBO 50031 BBF-H-D-05 Z)	
10 Perceiver Cain	1024	
11 Polovation Dolay	2 0000	
12 Pulso Width	10,0000	
12 Fulse Width	1 0398	
14 Spectrometer Frequency	125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1887.0	
17 Nucleus	130	
18 Acquired Size	32768	
10 Spectral Size	65536	
19 Spectral Size		
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-1 f1 (ppm) Ó



f1 (ppm)



f1 (ppm)

Parameter	Value				0 H 20	Br
1 Origin	Bruker BioSpin GmbH				1.6	
2 Owner	user1d					Br Me
3 Instrument	spect					
4 Solvent	CDCI3					
5 Temperature	296.1					
6 Pulse Sequence	zg30					
7 Experiment	1D					
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)					
9 Number of Scans	16					
10 Receiver Gain	55.0					
11 Relaxation Delay	10.0000					
12 Pulse Width	12.0000					
13 Acquisition Time	3.2768					
14 Spectrometer Frequency	500.35					
15 Spectral Width	10000.0					
16 Lowest Frequency	-1922.9					
17 Nucleus	1H					
18 Acquired Size	32768					
19 Spectral Size	65536					
	1					
		1				
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	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.1
6	Pulse Sequence	zgpg30
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	2048
10	Receiver Gain	190.5
11	Relaxation Delay	2.0000
12	Pulse Width	10.0000
13	Acquisition Time	1.0398
14	Spectrometer Frequency	125.83
15	Spectral Width	31512.6
16	Lowest Frequency	-1876.1
17	Nucleus	13C
18	Acquired Size	32768
19	Spectral Size	65536



Parameter	Value	CDCI3
1 Origin	Varian	7.26
2 Spectrometer	inova	Ĩ
3 Solvent	CDCI3	
4 Temperature	20.0	
5 Pulse Sequence	s2pul	
6 Experiment	1D	
7 Probe	QUAD	
8 Number of Scans	16	
9 Receiver Gain	60	
10 Relaxation Delay	2.0000	
11 Pulse Width	6.5000	
12 Acquisition Time	4.6645	
13 Spectrometer Frequency	499.69	
14 Spectral Width	7024.9	
15 Lowest Frequency	-1022.0	
16 Nucleus	1H	
17 Acquired Size	32768	
18 Spectral Size	65536	
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Parameter	Value	6 CDCI3			N N N N H
1 Origin	Varian	7.2			OHOH
2 Spectrometer	inova				Me
3 Solvent	CDCI3				Me
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	quadbp				
8 Number of Scans	16				
9 Receiver Gain	46				
10 Relaxation Delay	0.0000				
11 Pulse Width	5.8250				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	399.74				
14 Spectral Width	8000.0				
15 Lowest Frequency	-2427.9				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
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5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 1.0

Parameter	Value		<del>8</del>		
1 Origin	Bruker BioSpin GmbH				580.0A0
2 Spectrometer	spect		i l		Si Me
3 Solvent	CDCI3				Me
4 Temperature	296.1				
5 Pulse Sequence	zgpg30				
6 Experiment	1D				
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-	05 Z)			
8 Number of Scans	368				
9 Receiver Gain	190.5				
10 Relaxation Delay	2.0000				
11 Pulse Width	10.0000				
12 Acquisition Time	1.0398				
13 Spectrometer Frequency	125.83				
14 Spectral Width	31512.6				
15 Lowest Frequency	-1898.5				
16 Nucleus	13C				
17 Acquired Size	32768				
18 Spectral Size	65536				
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Parameter	Value	CDCI3			Me COOMe
1 Origin	Bruker BioSpin GmbH	7.26			
2 Spectrometer	spect				C C
3 Solvent	CDCI3				N YO
4 Temperature	296.2				
5 Pulse Sequence	zg30				
6 Experiment	1D				
7 Probe	Z127784_0002 (CP BBO 500S1 B	BF-H-D-05 Z)			
8 Number of Scans	16			I	
9 Receiver Gain	190.5	1			
10 Relaxation Delay	10.0000				
11 Pulse Width	12.0000				
12 Acquisition Time	3.2768				
13 Spectrometer Frequence	zy 500.35				
14 Spectral Width	10000.0				
15 Lowest Frequency	-1706.7				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
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Par	rameter			Value																
1 Origin	Br	uker BioSp	oin GmbH	1								1								
2 Spectrome	eter sp	ect										17.					6	=	CI	
3 Solvent	CI	DCI3															1		0	
4 Temperat	ure 29	6.1																		
5 Pulse Sequ	uence zg	pg30																		
6 Experimer	nt 1[	)																		
7 Probe	Z1	27784_00	002 (CP E	BO 5005	51 BBF-⊢	I-D-05	Z)													
8 Number o	of Scans 36	8																		
9 Receiver C	Gain 19	0.5																		
10 Relaxatior	n Delay 2.	0000																		
11 Pulse Wid	th 10	.0000																		
12 Acquisitio	on Time 1.	0398																		
13 Spectrome	eter Frequency 12	5.83																		
14 Spectral W	Vidth 31	512.6																		
15 Lowest Fre	equency –1	898.7																		
16 Nucleus	13	С																		
17 Acquired	Size 32	768																		
18 Spectral S	ize 65	536																		
		iden (Tabla Land (T)		<b>Yin ali ibialai i</b> mtea	Lindel View, I. Julia				i da nila <sup>l</sup> unin m		il o calinda - Ékinik	i ni ili bio di s	Nadiliki kidalenak	<u>This and a second s</u>				ham ain a		
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30 220 21	0 200 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0 -1

f1 (ppm)

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Parameter	Value		CDCI3			
1 Origin	Varian		7.26			
2 Spectrometer	inova					Ns H
3 Solvent	CDCI3					
4 Temperature	20.0					
5 Pulse Sequence	s2pul					
6 Experiment	1D					
7 Probe	QUAD					
8 Number of Scans	16					
9 Receiver Gain	60					
10 Relaxation Delay	10.0000					
11 Pulse Width	6.5000					
12 Acquisition Time	4.6645					
13 Spectrometer Frequency	499.69					
14 Spectral Width	7024.9					
15 Lowest Frequency	-1021.8					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
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Parameter	Value			
1 Origin	Bruker BioSpin GmbH		ŧ	
2 Spectrometer	spect	ŕ		Ns H
3 Solvent	CDCI3			
4 Temperature	296.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	640			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1898.9			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
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30	22	0	210	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	-1
													f1 (ppm)	)											

<ol> <li>Origin</li> <li>Owner</li> <li>Instrument</li> <li>Solvent</li> </ol>	Bruker BioSpin GmbH user1d spect CDCI3 298.2	5.29	 	CI
<ol> <li>2 Owner</li> <li>3 Instrument</li> <li>4 Solvent</li> </ol>	user1d spect CDCl3 298.2	Ĭ		
<ul><li>3 Instrument</li><li>4 Solvent</li></ul>	spect CDCl3 298.2			
4 Solvent	CDCl3 298.2			
<b>- -</b>	298.2			
5 Temperature				
6 Pulse Sequence	zg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	16			
10 Receiver Gain	55.0			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequen	icy 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1921.8			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			

Parameter	Value		SO <sub>2</sub> Ph I N
1 Origin	Bruker BioSpin GmbH		
2 Owner	user1d		
3 Instrument	spect		
4 Solvent	CDCI3		
5 Temperature	298.2		
6 Pulse Sequence	zgpg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	512		
10 Receiver Gain	190.5		
11 Relaxation Delay	2.0000		
12 Pulse Width	10.0000		
13 Acquisition Time	1.0398		
14 Spectrometer Frequence	y 125.83		
15 Spectral Width	31512.6		
16 Lowest Frequency	-1877.0		
17 Nucleus	13C		
18 Acquired Size	32768		
19 Spectral Size	65536		
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Parameter	Value	CDCI3	CH2CI2	etOAc	etOAc 120 etOAc	
1 Origin	Bruker BioSpin GmbH	26 0	30 (	13 1	04 I 60 I 26 I	Ϋ́́Ύ́
2 Spectrometer	spect	- 2.	-5.	4.		NO O
3 Solvent	CDCI3	Ι	I	Ι		
4 Temperature	296.1					
5 Pulse Sequence	zg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 500S1 E	BF-H-D-05 Z)				
8 Number of Scans	16	I				
9 Receiver Gain	190.5					
10 Relaxation Delay	1.0000					
11 Pulse Width	12.0000					
12 Acquisition Time	3.2768					
13 Spectrometer Frequence	y 500.35					
14 Spectral Width	10000.0					
15 Lowest Frequency	-1922.3					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
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		WIN 1	j / l			
	M					





f1 (ppm)



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	- <u> </u>					·			·		·	·	·

Parameter	Value	CDCI3	Н2О	o F Br
1 Origin	Bruker BioSpin GmbH			O N
2 Spectrometer	spect			
3 Solvent	CDCI3			AcO-
4 Temperature	296.1			
5 Pulse Sequence	zg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1	BBF-H-D-05 Z)		
8 Number of Scans	16			
9 Receiver Gain	190.5			
10 Relaxation Delay	10.0000			
11 Pulse Width	12.0000			
12 Acquisition Time	3.2768			
13 Spectrometer Frequency	/ 500.35			
14 Spectral Width	10000.0			
15 Lowest Frequency	-1760.2			
16 Nucleus	1H			
17 Acquired Size	32768			
18 Spectral Size	65536			
		1		

1         Orlpin         Bruker BioSpin GmbH           2         Spectrometer         spectr           3         Solvent         CDCI3           4         Temperature         296.2           5         Pulse Sequence         zggg30           6         Experiment         ID           7         Probe         2122774_0002 (CP BBO 50051 BBF-H-D-05 Z)           8         Number of Scans         368           9         Receiver Gain         190.5           10         Relaxation Delay         2,0000           12         Acquisition Time         1,0000           13         Spectral Size         3,0000           14	O F Br
2         Spectrometer         spect         Acc           3         Solvent         CDCI3         Acc           4         Temperature         266.2         Solvence         Zopga30           5         Experiment         ID         Topperature         266.2           7         Probe         Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)         Acc         Acc           8         Number of Scans         368         9         Beceiver Cain         100.5           10         Resciver Cain         100.5         10         Resciver Cain         103.5           12         Acquisition Time         1.0398         13         512.6         15           13         SpectrainWith         3151.2.6         15         16         16           14         SpectrainWith         3151.2.6         15         17         Acquisiton Time         1.0398           13         SpectrainWith         3151.2.6         15         1.0         16           16         McLeus         1277.8         277.8         277.8         1.0           18         SpectrainSize         653.36         1.0         1.0         1.0         1.0         1.0         1.0         1.0	NN
3       Solvent       CDC13       CDC14         4       Temperature       295.2       Solvent       295.2         5       Puble Sequence       299.0       Solvent       10         6       Experiment       10       Solvent       10         7       Probe       2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)       Solvent       10         8       Number of Scans       568       Solvent       10         9       Receiver Gain       190.5       Solvent       10         10       Retaxition Time       1.0396       Solvent       10         12       Acquisition Time       1.0396       Solvent       10         13       Solvent Frequency       -1899.0       10       10         15       Lowest Frequency       -1899.0       10       10         16       Multer       32768       32768       32768       33         18       Spectral Size       6536       Solvent solvest in the solv	
4       Temperature       296.2         5       Pulse Sequence       29930         6       Experime       10         7       Probe       212784_0002 (CP BBO 50051 BBF-H-D-O5 Z)         8       Number of Scam       368         9       Receiver Gain       190.5         10       Relaxion Delay       20000         11       Pulse Width       10.0000         12       Acquisition Time       10.398         13       Spectrometer Frequency       125.83         14       Spectrometer Frequency       125.83         15       Lowesi Frequency       1499.0         15       Kockus       13C         17       Acquired Size       13C         18       Spectral Size       13C         19       Acquired Size       13C         14 </td <td></td>	
5       PUDe       2127784_0002 (CP BBO 50051 BBF-H-D-O5 Z)         6       Experiment       10         7       Probe       2127784_0002 (CP BBO 50051 BBF-H-D-O5 Z)         8       Number of Scans       368         9       Receiver Gain       100.000         11       Pube With       10.0000         12       Acquistion Delay       2.0000         13       Puttownet Frequency       125.83         14       Spectrometer Frequency       125.83         15       Lowest Frequency       1390.0         16       Nucleus       3C         17       Acquisted Size       32768         18       Spectrand Size       65336	
6         Experiment         10           7         Probe         2127784_0002 (CP BB0 50051 BBF-H+D-05 2)           8         Number of Scans         368           9         Receiver Cain         100.5           10         Relaxation Delay         2.0000           11         Public With         10.0000           12         Acquisition Time         1.0398           13         Spectrometer Frequency         125.83           14         Spectrometer Frequency         125.83           15         Lowest Frequency         1.899.0           16         Nucleus         32           17         Acquisition Time         1.32768           18         Spectral With         312.2           17         Acquired Size         32768           18         Spectral Size         6536	
7       Probe       2127784_0002 (CP BB0 50051 BBF-H-D-05 2)         8       Number of Stams       368         9       Reciver Gain       190.5         10       Relaxation Delay       2.0000         11       Pube Width       0.0000         12       Aquistion Time       1.0398         13       Spectrometer Frequency       125.83         14       Spectral Width       31512.6         15       Lowest Frequency       1389.0         16       Nucleus       32768         18       Spectral Size       65536	
8       Number of Scans       368         9       Receiver Gain       190.5         10       Relaxation Delay       2.0000         11       Pulse Width       10.0398         12       Acquisition Time       1.0398         13       Spectrometer Frequency       25.83         14       Spectrometer Frequency       1.899.0         16       Nucleus       13C         17       Acquired Size       32768         18       Spectral Size       6536	
9       Receiver Gain       190.5         10       Relaxation Delay       2.000         11       Plake Width       10.0000         12       Acquisition Time       1.0398         13       Spectrometer Frequency       125.83         14       Spectrometer Frequency       125.83         15       Lowest Frequency       1.899.0         16       Nocleus       13C         17       Acquired Size       32768         18       Spectral Size       65536	
10       Relaxation Delay       2.0000         11       Puis Width       10.0000         12       Acquisition Time       10.398         13       Spectrometer Frequency       125.83         14       Spectral Width       31512.6         15       Lowest Frequency       -18930         16       Nucleus       312         17       Acquired Size       32768         18       Spectral Size       65536	
11       Pulse Width       10.0000         12       Acquisition Time       1.0398         13       Spectrometer Frequency       1.512.6         14       Spectral Width       31512.6         15       Lowest Frequency       -1899.0         16       Nucleus       3C         17       Acquired Size       32768         18       Spectral Size       6536	
12       Acquisition Time       1.0398         13       Spectrometer Frequency       125.83         14       Spectral Width       31512.6         15       Lowest Frequency       1.899.0         16       Nucleus       3C         17       Acquired Size       32768         18       Spectral Size       6536	
13       Spectral Width       31512.6         14       Spectral Width       31512.6         15       Lowest Frequency       -1899.0         16       Nucleus       3276         17       Acquired Size       32768         18       Spectral Size       6536	
14       Spectral Width       31512.6         15       Lowest Frequency       -189.0         16       Nucleus       13C         17       Acquired Size       32768         18       Spectral Size       65536	
15 Lowest Frequency       -1899.0         16 Nucleus       13C         17 Acquired Size       32768         18 Spectral Size       65536	
16 Nucleus       13C         17 Acquired Size       32768         18 Spectral Size       6536	
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	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Spectrometer	spect
3	Solvent	CDCI3
4	Temperature	296.2
5	Pulse Sequence	zgflqn
6	Experiment	1D
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
8	Number of Scans	48
9	Receiver Gain	190.5
10	Relaxation Delay	10.0000
11	Pulse Width	15.0000
12	Acquisition Time	0.5767
13	Spectrometer Frequency	470.75
14	Spectral Width	113636.4
15	Lowest Frequency	-103898.1
16	Nucleus	19F
17	Acquired Size	65536
18	Spectral Size	131072



Parameter	Value	5 H2C	F L
1 Origin	Bruker BioSpin GmbH	-1.5	
2 Owner	user1d	I	
3 Instrument	spect		
4 Solvent	CDCI3		OAc
5 Temperature	298.2		└ <sub>N</sub> ノ
6 Pulse Sequence	zg30		Ns
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	16		
10 Receiver Gain	122.8		
11 Relaxation Delay	10.0000		
12 Pulse Width	12.0000		
13 Acquisition Time	3.2768		
14 Spectrometer Frequency	500.35		
15 Spectral Width	10000.0		
16 Lowest Frequency	-1921.8		
17 Nucleus	1H		
18 Acquired Size	32768		
19 Spectral Size	65536		

Parameter 1 Origin 2 Owner	Value Bruker BioSpin GmbH user1d	F
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	298.2	N
6 Pulse Sequence	zgpg30	NS
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	256	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequency	/ 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1873.6	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	
Annunite augusta annun annu	สมาราครามและคุณราครามสาวารีการสมาร์การสมาราวการสาวที่หวามสาวารที่สาวการสาวารการสาวารการสาวารการสาวารการสาวารการ	งที่สุขสามกระบบที่ ในสะมากกรุญสนุกรรมสุของสมุของสมุของสมุของสมุของสมุของสมุของสมุของสุของสุของสุของสุของสุของส

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30	220	210	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	-1
												f1 (ppm)	)											~

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.1
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072



Parameter	Value	
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	O'
3 Instrument	spect	N N
4 Solvent	CDCI3	N=
5 Temperature	298.2	CF <sub>3</sub>
6 Pulse Sequence	zg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	16	
10 Receiver Gain	29.7	
11 Relaxation Delay	10.0000	
12 Pulse Width	12.0000	
13 Acquisition Time	3.2768	
14 Spectrometer Frequence	500.35	
15 Spectral Width	10000.0	
16 Lowest Frequency	-1920.8	
17 Nucleus	1H	
18 Acquired Size	32768	
19 Spectral Size	65536	

Parameter	Value		Me
1 Origin	Bruker BioSpin GmbH		
2 Owner	user1d		o' [ ]
3 Instrument	spect		N N
4 Solvent	CDCI3		Ň=
5 Temperature	298.2		CF <sub>3</sub>
6 Pulse Sequence	zgpg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	1024		
10 Receiver Gain	190.5		
11 Relaxation Delay	2.0000		1
12 Pulse Width	10.0000		
13 Acquisition Time	1.0398		
14 Spectrometer Frequence	ry 125.83		
15 Spectral Width	31512.6		
16 Lowest Frequency	-1903.3		
17 Nucleus	13C		
18 Acquired Size	32768		
19 Spectral Size	65536		
		//	

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	Parameter	Value	
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	
3	Instrument	spect	
4	Solvent	CDCI3	
5	Temperature	296.1	
6	Pulse Sequence	zgflqn	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-	-H-D-05 Z)
9	Number of Scans	16	
10	Receiver Gain	190.5	
11	Relaxation Delay	1.0000	
12	Pulse Width	15.0000	
13	Acquisition Time	0.5767	
14	Spectrometer Frequency	470.75	
15	Spectral Width	113636.4	
16	Lowest Frequency	-103898.1	
17	Nucleus	19F	
18	Acquired Size	65536	
19	Spectral Size	131072	

Me N S O V V CF3

Parameter	Value	5 CDCl3				
1 Origin	Bruker BioSpin GmbH	7.26				Ns COOMe
2 Spectrometer	spect					
3 Solvent	CDCI3					
4 Temperature	296.2					
5 Pulse Sequence	zg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 500S1 E	BBF-H-D-05 Z)				
8 Number of Scans	16					
9 Receiver Gain	137.4					
10 Relaxation Delay	10.0000					
11 Pulse Width	12.0000					
12 Acquisition Time	3.2768					
13 Spectrometer Frequency	500.35					
14 Spectral Width	10000.0					
15 Lowest Frequency	-1713.7					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
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					N AND N	
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rigin       Bruker BioSpin GmbH         pectrometer       Spect         olvent       CDCI3         emperature       296.2         ulse Sequence       zgpg 30         spectrom       10         orbo       2127784_0002 (CP BB0 50051 BBF-H-D-05.2)         umber of Scans       368         seciver Cain       10.0000         ulse Width       10.0000         cquisition Time       10.398         pectraf Width       3151.6         owest Frequency       125.6         pectraf Width       3151.6         owest Frequency       12768         pectraf Nick       5536
Spectrometer         spect           Solvent         CDC3           Temperature         296.2           Pulue Sequence         zapp30           Experiment         10           Probe         2127784_0002 (CP BB0 500S1 BBF-H-D-0 5 2)           Number of Scans         368           Receiver Gain         19.05           Readewing Data         10.0000           Adata         10.398           Spectrometer Frequery         125.85           Spectral Widt         1512.65           Spectral Size         3768           Spectral Size         32768           Spectral Size         6536
Solvent         CDCl3           Temperature         296.2           Pulse Sequence         zpp30           Experiment         10           Probe         Z127784_0002 (CP BBO S00S1 BBF-H-D-05 Z)           Number of Scans         368           Receiver Gain         190.5           Palkaxiton Delay         2.0000           Pulse Width         1.0000           Aquisition Time         1.039.8           Spectrometer Frequency         125.83           Spectrometer Frequency         125.83           Spectrometer Frequency         13512.6           Lowest Frequency         1300.1           Nucleus         32768           Spectrometer Streage         536
Temperature         296.2           Pulse Sequence         2pp930           Experiment         10           Probe         2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)           Number of Scans         368           Receiver Gain         190.5           O Relaxation Delay         2.0000           1 Pulse Width         10.0000           2 Acquistion Time         1.0398           3 Spectromet Frequency         1512.6           5 Lowest Frequency         -1900.1           6 Nucleus         32768           8 Spectral Size         65536
Puise Sequence       2gg30         Experiment       10         Probe       2127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)         Number of Scans       368         Receiver Gain       190.5         0 Relaxation Delay       2.0000         1 Puise Width       10.0900         2 Acquisition Time       1.0398         3 Spectrometer Frequency       125.83         4 Spectral Width       3151.6         5 Lowest Frequency       1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
Experime         1D           Probe         Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)           Number of Scans         368           Receiver Can         190.5           0 Relaxation Delay         2.0000           1 Pulse Width         10.0000           2 Acquistion Time         1.0398           3 Spectrometer Frequency         152.66           5 Lowest Frequency         -1900.1           6 Nucleus         32756           8 Spectral Size         65536
Probe       Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)         Number of Scans       368         Receiver Gain       190.5         D Relaxation Dalya       2.0000         1 Pulse Width       10.000         2 Acquistion Time       1.0398         3 Spectral Width       31512.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
Number of Scans       368         Receiver Gain       190.5         0 Relaxation Delay       2.0000         1 Pulse Width       10.0000         2 Acquisition Time       1.0398         3 Spectrometer Frequency       125.83         4 Spectral Width       3151.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
n         Receiver Gain         190.5           0         Relaxation Delay         2.0000           1         Pulse Width         10.000           2         Acquisition Time         1.0398           3         Spectrometer Frequency         125.83           4         Spectral Width         31512.6           5         Lowest Frequency         -1900.1           6         Nucleus         13C           7         Acquired Size         32768           8         Spectral Size         65536
0 Relaxation Delay       2.0000         1 Pulse Width       10.0000         2 Acquisition Time       1.0398         3 Spectrometer Frequency       125.83         4 Spectral Width       31512.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
1 Pulse Width       10.0000         2 Acquisition Time       1.0398         3 Spectrometer Frequency       125.83         4 Spectral Width       3151.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
2 Acquisition Time       1.0398         3 Spectrometer Frequency       125.83         4 Spectral Width       31512.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
3 Spectrometer Frequency       125.83         4 Spectral Width       31512.6         5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
4 Spectral Width 31512.6 5 Lowest Frequency -1900.1 6 Nucleus 13C 7 Acquired Size 32768 8 Spectral Size 65536
5 Lowest Frequency       -1900.1         6 Nucleus       13C         7 Acquired Size       32768         8 Spectral Size       65536
6 Nucleus 13C 7 Acquired Size 32768 8 Spectral Size 65536
7 Acquired Size 32768 8 Spectral Size 65536
8 Spectral Size 65536

Parameter	Value	CDCI3		ме
1 Origin	Bruker BioSpin GmbH	.26		
2 Spectrometer	spect	- 7		
3 Solvent	CDCI3	•		
4 Temperature	296.1			O Bu
5 Pulse Sequence	zq30			
6 Experiment	1D			
7 Probe	Z127784 0002 (CP BBO 500S1	BBF-H-D-05 Z)		
8 Number of Scans	16	·		
9 Receiver Gain	168.2			
10 Relaxation Delay	10.0000			
11 Pulse Width	12.0000			
12 Acquisition Time	3.2768			
13 Spectrometer Frequenc	y 500.35			
14 Spectral Width	10000.0			
15 Lowest Frequency	-1760.2			
16 Nucleus	1H			
17 Acquired Size	32768			
18 Spectral Size	65536			
		1		
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	II		MN	

2 3 4 5 6 7 8	Solvent	speci						<del>77.16 C</del>			$\cap$		e
4 5 6 7 8	bonrent	CDCI3											
5 6 7 8	Temperature	296.1									145	JT .	−O <sup>4</sup> Bu
6 7 8	Pulse Sequence	zgpg30											
7 8	Experiment	1D											
8	Probe	Z127784_0002 (CP I	BO 500S1 BE	3F-H-D-05	Z)								
	Number of Scans	368											
9	Receiver Gain	190.5											
1(	) Relaxation Delay	2.0000											
1	L Pulse Width	10.0000											
17	2 Acquisition Time	1.0398											
13	3 Spectrometer Frequency	125.83											
14	1 Spectral Width	31512.6											
1!	5 Lowest Frequency	-1899.4											
10	5 Nucleus	13C											
17	7 Acquired Size	32768											
18	3 Spectral Size	65536											
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10000000000000000000000000000000000000			160 15	1000 1400 1400 1400 1400 1400 1400 1400	, 1 130	принр <sup>и</sup> лтири пикана ( <b>крадина</b> ) 120 110	100 90	80 2	70 60	, <u> </u>		30 20 10 0	, ,

Parameter	Value	F O O
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	Br
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.2	
6 Pulse Sequence	zg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	16	
10 Receiver Gain	190.5	
11 Relaxation Delay	1.0000	
12 Pulse Width	12.0000	
13 Acquisition Time	3.2768	
14 Spectrometer Frequency	500.35	
15 Spectral Width	10000.0	
16 Lowest Frequency	-1923.3	
17 Nucleus	1Н	
18 Acquired Size	32768	
19 Spectral Size	65536	

Parameter	Value			
1 Origin	Bruker BioSpin GmbH			
2 Owner	user1d			Br
3 Instrument	spect			
4 Solvent	CDCI3			
5 Temperature	296.1			
6 Pulse Sequence	zgpg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	2048			
10 Receiver Gain	190.5			
11 Relaxation Delay	2.0000			
12 Pulse Width	10.0000			
13 Acquisition Time	1.0398			
14 Spectrometer Frequency	125.83			
15 Spectral Width	31512.6			
16 Lowest Frequency	-1916.9			
17 Nucleus	13C			
18 Acquired Size	32768			
19 Spectral Size	65536			
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~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		lanumum harrows	๛๛โ๛๛๛โ๛๛๛๛๛๛๛๛๛๛	ไขของสามมีและสามาร์ (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.2
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072





.0 11.5 11.0 10.5 10.0 9.5 9.0 8.0 7.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 8.5 7.0 6.5 6.0 1.0 f1 (ppm)

Parameter	Value	N=N, N-Me
1 Origin	Bruker BioSpin GmbH	
2 Spectrometer	spect	
3 Solvent	CDCI3	O, N F
4 Temperature	296.1	$\sim$
5 Pulse Sequence	zgpg30	AcO-
6 Experiment	1D	
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
8 Number of Scans	368	
9 Receiver Gain	190.5	
10 Relaxation Delay	2.0000	
11 Pulse Width	10.0000	
12 Acquisition Time	1.0398	
13 Spectrometer Frequency	125.83	
14 Spectral Width	31512.6	
15 Lowest Frequency	-1916.9	
16 Nucleus	13C	
17 Acquired Size	32768	
18 Spectral Size	65536	
30 220 210 200 1	90 180 170 160 150 140 130 120 110 100 90 80 f1 (ppm)	0 70 60 50 40 30 20 10 0 -1

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Spectrometer	spect
3	Solvent	CDCI3
4	Temperature	296.1
5	Pulse Sequence	zgflqn
6	Experiment	1D
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
8	Number of Scans	80
9	Receiver Gain	190.5
10	Relaxation Delay	10.0000
11	Pulse Width	15.0000
12	Acquisition Time	0.5767
13	Spectrometer Frequency	470.75
14	Spectral Width	113636.4
15	Lowest Frequency	-103898.1
16	Nucleus	19F
17	Acquired Size	65536
18	Spectral Size	131072





.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0 f1 (ppm)

Parameter 1 Origin 2 Spectrometer 3 Solvent	Value Bruker BioSpin GmbH spect CDCI3		77.1.5 CDCI3	Me N N OAc
4 Temperature	296.2			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			1
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1902.4			
16 Nucleus	13C			
17 Acquired Size	32768			
ŧndiābanovatorus pilijarovija/vilik-toruspaskytorijeidosaus sporagotija			I bridge have be reversed agreed and boy his marine of the set of the line of	
30 220 210 200	190 180 170 160 150 140 1	30 120 110 100 90 80 f1 (ppm)	70 60 50 40 30	20 10 0 -1



Parameter	Value O		Me
1 Origin	Bruker BioSpin GmbH		№,ОН
2 Spectrometer	spect		
3 Solvent	CDCI3		<pre>&gt;&gt; `0' \</pre>
4 Temperature	296.2		major
5 Pulse Sequence	zg30		
6 Experiment	1D		
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
8 Number of Scans	16		
9 Receiver Gain	168.2		
10 Relaxation Delay	1.0000		
11 Pulse Width	12.0000		
12 Acquisition Time	3.2768		
13 Spectrometer Frequency	500.35		
14 Spectral Width	10000.0		
15 Lowest Frequency	-1922.0		
16 Nucleus	1H		
17 Acquired Size	32768		
18 Spectral Size	65536		
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Parameter	Value			<del>9001</del>		
1 Origin	Bruker BioSpin GmbH			9 		8. И И И И И И И И И И И И И И И И И И И
2 Spectrometer	spect			1		- 59
3 Solvent	CDCl3					0
4 Temperature	296.1					major
5 Pulse Sequence	zgpg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05	5 Z)				
8 Number of Scans	7680					
9 Receiver Gain	190.5					
10 Relaxation Delay	0.7500					
11 Pulse Width	10.0000					
12 Acquisition Time	1.0398					
13 Spectrometer Frequency	/ 125.83					
14 Spectral Width	31512.6					
15 Lowest Frequency	-1899.7					
16 Nucleus	13C					
17 Acquired Size	32768					
18 Spectral Size	65536					
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				л II		
₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩	ระชุษาระทับแนนกะจุมหารหนูAnnovembarisanianinaninanipungAnnoversaninaninanipung	anon Vinatawanana kananananan	หมู่ใ <sub>นอาจอาสตรรณหาราชการสองการสองการส</sub>	And have a second	alan waanamaana	under Hall between the and the second s

ר 1–1 f1 (ppm) ò



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0 f1 (ppm)

Parameter	Value					
1 Origin	Bruker BioSpin GmbH				9 	50 N,ОН
2 Spectrometer	spect				r. F.	- 29
3 Solvent	CDCI3					~ .0. /
4 Temperature	296.2					minor
5 Pulse Sequence	zgpg30					
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 5	00S1 BBF-H-D-05 Z)				
8 Number of Scans	368					
9 Receiver Gain	190.5					
10 Relaxation Delay	2.0000					
11 Pulse Width	10.0000					
12 Acquisition Time	1.0398					
13 Spectrometer Frequency	125.83					
14 Spectral Width	31512.6					
15 Lowest Frequency	-1916.9					
16 Nucleus	13C					
17 Acquired Size	32768		1			
18 Spectral Size	65536	1				
Afashina da Aran Indone Afan kakan kak	la iku ana ika kata kana ana ana ana ana ana ana ana ana a	id haaf dis fan de sterrek in de sterrek	Anandi Allinini ada funikina atria inai inai k	rinafatirini datati tutalitanihan (tuta na m	n. Milanddad Antonin Manada Ulfanda in Maanalu dalan nu	rl fen 11 føru u nær i nærn skalar u Lit forskin om dæfra formaligen en nøkt ut Minareforsken lærn
30 220 210 200 1	190 180 170 160	0 150 140 130	0 120 110 f1 (ppm)	100 90 80	70 60 50 4	0 30 20 10 0 -1



5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 6.5 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 7.0 6.0 1.0



Parameter	Value	CDCI3				Me
1 Origin	Varian	26				Mie COOMie
2 Spectrometer	inova					
3 Solvent	CDCI3					
4 Temperature	20.0					
5 Pulse Sequence	s2pul					
6 Experiment	1D					
7 Probe	QUAD					
8 Number of Scans	16					
9 Receiver Gain	60					
10 Relaxation Delay	10.0000					
11 Pulse Width	6.5000					
12 Acquisition Time	4.6645					
13 Spectrometer Frequency	499.69	1				
14 Spectral Width	7024.9				1	
15 Lowest Frequency	-1021.8					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
			١			
				<u>N</u>		
	~**~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	/ Lune / Lune		al Lamon more more more more than the second	/VUL	

	Parameter	Value	
1	Origin	Bruker BioSpin GmbH	
2	Spectrometer	spect	
3	Solvent	CDCI3	<u>``</u>
4	Temperature	296.2	
5	Pulse Sequence	zgpg30	
6	Experiment	1D	
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
8	Number of Scans	2560	
9	Receiver Gain	190.5	
1	0 Relaxation Delay	2.0000	
1	1 Pulse Width	10.0000	
1	2 Acquisition Time	1.0398	
1	3 Spectrometer Frequency	125.83	
1	4 Spectral Width	31512.6	
1	5 Lowest Frequency	-1900.0	
1	6 Nucleus	13C	
1	7 Acquired Size	32768	
1	8 Spectral Size	65536	
www.	wynd/gwrliedelau godfrofweregy di dio faro y dewnloed adwyad	กลางสามารถแก่งสามารถการสามารถการสามารถการสามารถการสามารถการการการการสามารถการสามารถการสามารถการสามารถการการการก	/ โละสารแกะสารที่สารแกะสารแกะสารแกะสารแกะสารและสารแส่งเหลือและสารและสารและสารและสารและสารและสารและสารและสารแกะ



f1 (ppm)



f1 (ppm)

Parameter	Value	CDCI3		H2O Grease	Me
1 Origin	Bruker BioSpin GmbH	.26		53	
2 Spectrometer	spect	~			$\sim$ $\sim$
3 Solvent	CDCI3				
4 Temperature	296.1				
5 Pulse Sequence	zg30				
6 Experiment	1D				
7 Probe	Z127784_0002 (CP BBO 500S1	BBF-H-D-05 Z)			
8 Number of Scans	16				
9 Receiver Gain	107.0				
10 Relaxation Delay	10.0000				
11 Pulse Width	12.0000				
12 Acquisition Time	3.2768				
13 Spectrometer Frequency	/ 500.35				
14 Spectral Width	10000.0				
15 Lowest Frequency	-1922.5				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536			i i	
		A line and the second sec			

Parameter	Value			Me
1 Origin	Bruker BioSpin GmbH	U C		
2 Spectrometer	spect	' 1		$\sim$
3 Solvent	CDCI3			-
4 Temperature	296.2			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	2048			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequence	y 125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1887.4	1		
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
\/~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			/1	

-1 f1 (ppm) Ó



5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 1.0

Parameter          1       Origin         2       Spectrometer         3       Solvent         4       Temperature         5       Pulse Sequence         6       Experiment         7       Probe         8       Number of Scans         9       Receiver Gain         10       Relaxation Delay         11       Pulse Width         12       Acquisition Time         13       Spectrometer Frequency         14       Spectral Width         15       Lowest Frequency	Value  Bruker BioSpin GmbH spect CDCI3 296.2 zgpg30 1D Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z) 368 190.5 2.0000 10.0000 1.0398 (125.83 31512.6 -1900.1 12C		-29.84 Grease $Me^{(minor)}$
16 Nucleus 17 Acquired Size	32768		
18 Spectral Size			



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 1.0 f1 (ppm)

Parameter	Value			Me N
1 Origin	Bruker BioSpin GmbH	P F		
2 Spectrometer	spect	1		Me <sup>we</sup> Boc
3 Solvent	CDCI3			+ Me
4 Temperature	296.2			)_N
5 Pulse Sequence	zgpg30			
6 Experiment	1D			Me Nac (minor)
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			Bue (minor)
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1899.0			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
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.0 11.5 11.0 10.5 10.0 9.5 9.0 8.0 7.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 8.5 7.0 6.5 6.0 1.0 f1 (ppm)

Parameter	Value	SO <sub>2</sub> Ph I N Me
1 Origin	Bruker BioSpin GmbH	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
2 Owner	user1d	CI
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.2	
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	2048	
10 Receiver Gain	190.5	
11 Relaxation Delay	1.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequency	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1888.3	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) ò







Parameter	Value			F
1 Origin	Bruker BioSpin GmbH			Me
2 Owner	user1d			N N
3 Instrument	spect			O Me
4 Solvent	CDCI3			
5 Temperature	296.2			N Me
6 Pulse Sequence	zg30			
7 Experiment	1D			
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9 Number of Scans	16			
10 Receiver Gain	29.7			
11 Relaxation Delay	10.0000			
12 Pulse Width	12.0000			
13 Acquisition Time	3.2768			
14 Spectrometer Frequence	y 500.35			
15 Spectral Width	10000.0			
16 Lowest Frequency	-1954.1			
17 Nucleus	1H			
18 Acquired Size	32768			
19 Spectral Size	65536			
	, JIVI I M.		II. II	
			IVN. II.a.a.	
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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	F
1 Origin	Bruker BioSpin GmbH	Me
2 Owner	user1d	
3 Instrument	spect	Me Me
4 Solvent	CDCI3	
5 Temperature	296.1	N × Me
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	1024	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequency	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1904.9	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	
	─────┴┟───╢ <b>╶╢</b> ╶╢ <u>╶╢</u> ╶╢┟┟┟┟╎╎─────╢───╎───╎───	

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30	220	210	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	-1
												f1 (ppm)	)											

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.1
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072



Parameter	Value	CDCI3		ci ci
1 Origin	Varian	7.26		Ϋ́́Ύ́
2 Spectrometer	inova			Wer NO
3 Solvent	CDCI3			Me
4 Temperature	20.0			
5 Pulse Sequence	s2pul			
6 Experiment	1D			
7 Probe	QUAD			
8 Number of Scans	0			
9 Receiver Gain	41			
10 Relaxation Delay	10.0000			
11 Pulse Width	6.5000			
12 Acquisition Time	4.6645			
13 Spectrometer Frequency	499.69			
14 Spectral Width	7024.9			
15 Lowest Frequency	-984.5			
16 Nucleus	1H			
17 Acquired Size	32768			
18 Spectral Size	65536			
			Grease	

Parameter	Value		enci3		Crease
1 Origin	Bruker BioSpin GmbH		9 		58.
2 Spectrometer	spect		7		-20 -20 -20
3 Solvent	CDCI3				
4 Temperature	296.1				Me
5 Pulse Sequence	zgpg30				
6 Experiment	1D				
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)				
8 Number of Scans	1280				
9 Receiver Gain	190.5				
10 Relaxation Delay	2.0000				
11 Pulse Width	10.0000				
12 Acquisition Time	1.0398				
13 Spectrometer Frequency	/ 125.83				
14 Spectral Width	31512.6				
15 Lowest Frequency	-1899.6				
16 Nucleus	13C				
17 Acquired Size	32768				
18 Spectral Size	65536				
230 220 210 200	190 180 170 160 150 140	130 120 110 100 9 f1 (ppm)	0 80 70	60 50 40	30 20 10 0 -10 298

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.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 6.0 f1 (ppm)

Parameter	Value	CDCI3		
1 Origin	Bruker BioSpin GmbH	7.16		AcO
2 Spectrometer	spect			Me
3 Solvent	CDCI3			
4 Temperature	296.1			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	368			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequence	/ 125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1902.6			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
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-1 f1 (ppm) ò

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Spectrometer	spect
3	Solvent	CDCI3
4	Temperature	296.2
5	Pulse Sequence	zgflqn
6	Experiment	1D
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
8	Number of Scans	16
9	Receiver Gain	190.5
10	Relaxation Delay	10.0000
11	Pulse Width	15.0000
12	Acquisition Time	0.5767
13	Spectrometer Frequency	470.75
14	Spectral Width	113636.4
15	Lowest Frequency	-103898.1
16	Nucleus	19F
17	Acquired Size	65536
18	Spectral Size	131072



a flar direfte kræðin far æðin fræðin fræðin fræðin fræðin af fræðin fræði	
.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 f1 (ppm)	4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2

Parameter	Value	H2O grease	F
1 Origin	Bruker BioSpin GmbH	1.25	
2 Owner	user1d		Ý
3 Instrument	spect		OAc
4 Solvent	CDCI3		
5 Temperature	296.2		Ne N Ns
6 Pulse Sequence	zg30		
7 Experiment	1D		
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9 Number of Scans	16		
10 Receiver Gain	137.4		
11 Relaxation Delay	10.0000		
12 Pulse Width	12.0000		
13 Acquisition Time	3.2768		
14 Spectrometer Frequence	/ 500.35		
15 Spectral Width	10000.0		
16 Lowest Frequency	-1922.8		
17 Nucleus	1H		
18 Acquired Size	32768		
19 Spectral Size	65536		

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

1 Origin Burker BiaSpin CmBH   2 Owner user1d   3 Instrume Sect   4 Solvent COCI3   5 Femperature 296-2   6 Puise Sequence 29930   7 Experiment 10   8 Probe 2127764,0002 (CP BBO 50051 BF-H-D-05 Z)   9 Number of Scans 2048   10 Receiver Call 390-5   11 Relaxation Delay 2.0000   12 Puise Wath 10.0000   13 Acquistion 10 10.0398   14 Spectrometer Frequency 25.83   15 Spectral Wath 13512.6   16 Lowest Frequency -1899.9   17 Nucleus 1370-8   19 Spectral Size 6536	Parameter	Value	F
2 Owner usrLd   3 instrument spect   4 Solvent CDCI3   5 Temperature 295.2   6 Pulse Sequence zggg30   7 Experiment 10   8 Probe 2127784_0002 (CP BBO 50051 BBF-H+D=05 Z)   9 Number of Scans 2048   10 Receiver Gain 100.0000   13 Acquisition Time 1.0398   14 Spectral Width 10.0000   13 Acquisition Time 1.0398   14 Spectral Width 31512.6   16 Iscowst Frequency -1899.9   17 Nucleo 13C   18 Acquired Size 32768   19 Spectral Size 65336	1 Origin	Bruker BioSpin GmbH	
3 Instrument spect   4 Solvent CDC13   5 Temperature 296.2   6 Polas Sequence zpg30   7 Experime 10   8 Probe 2127784_0002 (CP 880 500S1 88F-H-D-05 Z)   9 Number of Scans 2048   10 Reciver Gamma 100.5   11 Relaxation Delay 2.0000   12 Pulse Multith 3151.2.6   13 Acquisition Time 1.0398   14 Spectrometer Frequency 25.83   15 Spectral Multith 3151.2.6   16 Lowast Prequency -1890.9   17 Nucleus 132C   18 Acquisition Time 1.32C   18 Acquised Size 32768   19 Spectral Multic 4535.4	2 Owner	user1d	Ý
4 Solvent CDC13   5 Temperature 296.2   6 Puise Sequence zgpg30   7 Experiment 10   8 Probe Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)   9 Number of Scans 2048   10 Receiver Gain 100.5   11 Relaxation Delay 2.0000   12 Puise Width 10.0000   13 Acquisition Time 1.0338   14 Spectromet Frequency 125.83 15   15 Spectral Width 31512.6   16 Lowst Frequency 25.83 13C   18 Acquired Size 32768   19 Spectral Size 65336	3 Instrument	spect	····``OAc
5 Temperature 296.2   6 Puise Sequence 29930   7 Experiment 10   8 Probe 2127784_0002 (CP BB0 50051 BBF-H-D-05 Z)   9 Number of Scans 2048   10 Receiver Gain 190.5   11 Relaxation Delay 2.0000   12 Puise Width 10.0000   13 Acquisition Time 1.0398   14 Spectrometer Frequency 125.83   15 Spectral Width 31512.6   16 Lowest Frequency 12.788.3   15 Spectral Width 3152.6   16 Lowest Frequency 12.788.3   17 Nucleus 132   19 Spectral Size 65336	4 Solvent	CDCI3	
6 Pules Sequence 2gpg30   7 Experiment 10   8 Probe Z127784_0002 (CP BB0 50051 BBT-H-D-05 Z)   9 Number of Scans 2048   10 Receiver Gain 190.5   11 Relaxation Delay 2.000   12 Pulse Width 10.000   13 Acquisiton Time 1.0398   14 Spectrometer Frequency 125.83   15 Spectral Width 3152.6   16 Lowest Frequency 1389.9   17 Nucleus 13C   18 Acquisiton Time 3.2768   19 Spectral Size 65536	5 Temperature	296.2	Me`N Ns
7   Experiment   D     8   Probe   2127784_0002 (CP BB0 50051 BBF-H-D-05 Z)     9   Number of Scans   2048     10   Receiver Cain   390.5     11   Relaxation Delay   2000     12   Pulse Width   0.0000     13   Acquisition Time   0.0398     14   Spectrometer Frequency   25.83     15   Spectral Width   31512.6     16   Lowest Frequency   1899.9     17   Nucleus   32768     19   Spectral Size   5536	6 Pulse Sequence	zgpg30	
8 Probe 2127784,0002 (CP BB0 500S1 BBF-H-D-05 Z)   9 Number of Scans 2048   10 Reciver Gain 190.5   11 Relaxation Delay 2.0000   12 Pulse Width 10.000   13 Acquisition Time 1.0398   14 Spectrameter Frequency 125.83   15 Spectral Width 3151.6   16 Lowest Frequency 1389.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	7 Experiment	1D	
9   Number of Scans   2048     10   Receiver Gain   190.5     11   Relaxation Delay   2.0000     12   Pulse Width   10.0000     13   Acquisition Time   1.0398     14   Spectrometer Frequency   125.83     15   Spectral Width   3151.6     16   Lowest Frequency   -1.899.9     17   Nucleos   13C     18   Acquired Size   32768     19   Spectral Size   65536	8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
10 Receiver Gain 1905   11 Relaxation Delay 2.0000   12 Pulse Width 10.0000   13 Acquisition Time 1.0398   14 Spectrometer Frequency 25.83   15 Spectral Width 31512.6   16 Lowest Frequency 1.899.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	9 Number of Scans	2048	
11 Relaxation Delay 2.000   12 Pulse Width 10.000   13 Acquisition Time 1.0398   14 Spectrometer Frequency 125.83   15 Spectral Width 31512.6   16 Lowest Frequency -1890.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 6536	10 Receiver Gain	190.5	
12 Pulse Width 10.0000   13 Acquisition Time 1.0398   14 Spectrometer Frequency 125.83   15 Spectral Width 3151.6   16 Lowest Frequency -1899.9   17 Nucleus 13C   18 Acquiried Size 32768   19 Spectral Size 65536	11 Relaxation Delay	2.0000	
13 Acquisition Time 1.0398   14 Spectrometer Frequency 125.83   15 Spectral Width 31512.6   16 Lowest Frequency -1899.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65336	12 Pulse Width	10.0000	
14 Spectrometer Frequency 125.83   15 Spectral Width 31512.6   16 Lowest Frequency -1899.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	13 Acquisition Time	1.0398	
15 Spectral Width 31512.6   16 Lowest Frequency -1899.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	14 Spectrometer Frequency	125.83	
16 Lowest Frequency -1899.9   17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	15 Spectral Width	31512.6	
17 Nucleus 13C   18 Acquired Size 32768   19 Spectral Size 65536	16 Lowest Frequency	-1899.9	
18 Acquired Size 32768   19 Spectral Size 65536	17 Nucleus	13C	
19 Spectral Size 65536	18 Acquired Size	32768	
	19 Spectral Size	65536	

ר 1– f1 (ppm) Ó

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.2
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072







	Parameter	Value	F
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	I Ý
3	Instrument	spect	OAc
4	Solvent	CDCI3	Mey
5	Temperature	296.2	Boc
6	Pulse Sequence	zg30	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9	Number of Scans	16	
10	Receiver Gain	55.0	
11	Relaxation Delay	10.0000	
12	Pulse Width	12.0000	
13	Acquisition Time	3.2768	
14	Spectrometer Frequency	500.35	
15	Spectral Width	10000.0	
16	Lowest Frequency	-1922.5	
17	Nucleus	1H	
18	Acquired Size	32768	
19	Spectral Size	65536	

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	F
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	Ý
3 Instrument	spect	OAc
4 Solvent	CDCI3	
5 Temperature	296.1	Boc
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	2048	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequenc	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1900.4	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	
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-1 f1 (ppm) ò

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.2
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072



Parameter	Value			grease	Me
1 Origin	Bruker BioSpin GmbH			.26	Ń Ś
2 Owner	user1d				Me O
3 Instrument	spect			,	N
4 Solvent	CDCI3				Ň=
5 Temperature	298.1				`СF <sub>3</sub>
6 Pulse Sequence	zg30				
7 Experiment	1D				
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)				
9 Number of Scans	16				
10 Receiver Gain	55.0				
11 Relaxation Delay	10.0000				
12 Pulse Width	12.0000				
13 Acquisition Time	3.2768				
14 Spectrometer Frequence	y 500.35				
15 Spectral Width	10000.0				
16 Lowest Frequency	-1919.8				
17 Nucleus	1H				
18 Acquired Size	32768				
19 Spectral Size	65536				
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LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	Me
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	Me O´´ [[ 〕] )
3 Instrument	spect	N
4 Solvent	CDCI3	N=
5 Temperature	298.2	ĊF <sub>3</sub>
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	1024	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequency	125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1887.4	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) Ó

	Parameter	Value	
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	
3	Instrument	spect	
4	Solvent	CDCI3	
5	Temperature	296.2	
6	Pulse Sequence	zgflqn	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-	-H-D-05 Z)
9	Number of Scans	16	
10	Receiver Gain	190.5	
11	Relaxation Delay	1.0000	
12	Pulse Width	15.0000	
13	Acquisition Time	0.5767	
14	Spectrometer Frequency	470.75	
15	Spectral Width	113636.4	
16	Lowest Frequency	-103898.1	
17	Nucleus	19F	
18	Acquired Size	65536	
19	Spectral Size	131072	

Me O N S Me O CF<sub>3</sub>

Parameter	Value	CDCI3		H2O	Me
1 Origin	Varian	26		1.57	Me <sup>Y</sup> Ns COOMe
2 Spectrometer	inova				
3 Solvent	CDCI3				
4 Temperature	20.0				
5 Pulse Sequence	s2pul				
6 Experiment	1D				
7 Probe	hcn				
8 Number of Scans	16		1		
9 Receiver Gain	42				
10 Relaxation Delay	0.0000				
11 Pulse Width	7.0000				
12 Acquisition Time	4.0960				
13 Spectrometer Frequency	500.07				
14 Spectral Width	8000.0				
15 Lowest Frequency	-1521.4				
16 Nucleus	1H				
17 Acquired Size	32768				
18 Spectral Size	65536				
				NN	

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value			Me
1 Origin	Bruker BioSpin GmbH			Me <sup>v</sup> Ns HN COOMe
2 Spectrometer	spect	F.		
3 Solvent	CDCI3			
4 Temperature	298.0			
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	1280			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1916.9			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
##U <sup>1</sup> 1447y###################################				
**/***********************************	ĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸ		<u>, ur head an shared by provide the second provided and the second s</u>	₩ <b>₽₽</b> ₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽₽









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-, -, -, -, -, -, -, -, -, -, -, -, -, -	5.2	5.0	4.8	4.6	4.4	4.2	4.0	3.8	3.6	3.4	3.2	3.0 f1 (ppm)	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	-



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1OriginBruker BioSpin GmbH2Spectrometerspect3SolventCDC134Temperature296.15Pulse Sequencezgpg306ExperimentID7Probe2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000012Acquisition Time1.039813Spectrometer Frequency1.899.416Nucleus3276818Spectral Size65536	$ \begin{array}{c} \begin{array}{c} \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ $
2 Spectrometer spect   3 Solvent CDCl3   4 Temperature 296.1   5 Pulse Sequence zgp30   6 Experiment ID   7 Probe Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)   8 Number of Scans 368   9 Receiver Gain 190.5   10 Relaxation Delay 2.0000   11 Pulse Width 10.0000   12 Acquisition Time 1.0398   13 Spectral Width 31512.6   15 Lowest Frequency -1899.4   16 Nucleus 13C   17 Acquired Size 32768   18 Spectral Size 65536	Me <sup>x<sup>+</sup></sup> Ns
3 Solvent CDC13   4 Temperature 296.1   5 Pulse Sequence zgpg30   6 Experiment ID   7 Probe Z127784_0002 (CP BBO 50051 BBF-H-D-05 Z)   8 Number of Scans 368   9 Receiver Gain 190.5   10 Relaxation Delay 2.0000   11 Pulse Width 10.0000   12 Acquisition Time 1.0398   13 Spectrometer Frequency 125.83   14 Spectral Width 31512.6   15 Lowest Frequency -1899.4   16 Nucleus 32768   17 Acquired Size 32768   18 Spectral Size 65536	we Ns
4Temperature296.15Pulse Sequencezgpg306ExperimentLD7Probe2127784_0002 (CP BBO 50051 BBF-H-D-05 Z)8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency3276818Spectral Size65536	
5Pulse Sequencezgpg306Experiment1D7Probe2127784_0002 (CP BB0 50051 BBF-H-D-05 Z)8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000011Pulse Width0.000012Acquisition Time1.039813Spectrometer Frequency25.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus3276818Spectral Size65536	
6Experiment1D7Probe2127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000011Pulse Width0.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.6615Lowest Frequency-1899.416Nucleus3276817Acquired Size5536	
7ProbeZ127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000011Pulse Width10.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus3276818Spectral Size5536	
8Number of Scans3689Receiver Gain190.510Relaxation Delay2.000011Pulse Width10.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus13C17Acquired Size3276818Spectral Size65536	
9Receiver Gain190.510Relaxation Delay2.000011Pulse Width10.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus3276818Spectral Size5536	
10Relaxation Delay2.000011Pulse Width10.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus13C17Acquired Size3276818Spectral Size65536	
11Pulse Width10.000012Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus13C17Acquired Size3276818Spectral Size65536	
12Acquisition Time1.039813Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus13C17Acquired Size3276818Spectral Size65536	
13Spectrometer Frequency125.8314Spectral Width31512.615Lowest Frequency-1899.416Nucleus13C17Acquired Size3276818Spectral Size65536	
14 Spectral Width31512.615 Lowest Frequency-1899.416 Nucleus13C17 Acquired Size3276818 Spectral Size65536	
15 Lowest Frequency-1899.416 Nucleus13C17 Acquired Size3276818 Spectral Size65536	
16 Nucleus13C17 Acquired Size3276818 Spectral Size65536	
17 Acquired Size 32768 18 Spectral Size 65536	
18 Spectral Size 65536	
	ารารศรีษณฑ์หนึ่งและการให้เราะอากา ใหม่หาวไฟมตามหาวย ไม่การรดีมีประกับไปสายให้เราะรูปไม่ได้เราะรูปและการประการเป



.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2.3 7.5 f1 (ppm)

Parameter	Value			Me Me O
1 Origin	Bruker BioSpin GmbH		9	
2 Spectrometer	spect		1	NH HN
3 Solvent	CDCI3			Me' Ns
4 Temperature	298.2			COO/Bu
5 Pulse Sequence	zgpg30			
6 Experiment	1D			
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
8 Number of Scans	1280			
9 Receiver Gain	190.5			
10 Relaxation Delay	2.0000			
11 Pulse Width	10.0000			
12 Acquisition Time	1.0398			
13 Spectrometer Frequency	125.83			
14 Spectral Width	31512.6			
15 Lowest Frequency	-1916.9			
16 Nucleus	13C			
17 Acquired Size	32768			
18 Spectral Size	65536			
Vadi fadi meteringan sekan kelangkan kelangkan kelangkan kelangkan kelangkan kelangkan kelangkan kelangkan kela	ฟอไฟไฟฟเกาอังเตอร์ไฟไฟต์อากรูปเหตุมารูปได้อยู่เสียรูดกัจรูปแห่งก่ายหรือรังหมู่มาให้หมารถดีไปจะของปัญหันรได้อาดย	ֈֈֈֈ֎֎ֈֈ՟՟֎֎ՠ֎ֈֈ <sup>ֈ</sup> ՠֈՠ֎ֈ֎֎ՠ֎ՠ֎ՠ֎ՠ֎ՠ֎ՠ֎ֈ֎֎ՠ֎ֈֈֈֈֈֈ֎֎ՠ֎ֈՠ֎ֈֈֈֈ֎֎ՠ֎ֈֈֈֈ֎ՠ֎ֈֈֈֈֈ֎ՠ֎ֈֈֈֈֈ֎ՠ֎ֈֈֈ֎֎ՠ֎ֈՠ֎ֈ	ĸĸĸĸĸĸĬĸĸĸŧĸſĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸĸ	annining film fa film far geland fra fan de fan de fan fan de
30 220 210 200	190 180 170 160 150 140	130 120 110 100 90	80 70 60 50 40	30 20 10 0 -

	Parameter	Value		Me Me
1	Origin	Bruker BioSpin GmbH		
2	Owner	user1d		Me
3	Instrument	spect		Me Me
4	Solvent	CDCI3		
5	Temperature	298.2		
6	Pulse Sequence	zg30		
7	Experiment	1D		
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)		
9	Number of Scans	16		
10	Receiver Gain	69.2		
11	Relaxation Delay	10.0000		
12	Pulse Width	12.0000		
13	Acquisition Time	3.2768		
14	Spectrometer Frequency	500.35		
15	Spectral Width	10000.0		
16	Lowest Frequency	-1922.3		
17	' Nucleus	1H		
18	Acquired Size	32768		
19	Spectral Size	65536		
		I		
			A I	K MA. ULAVIAN III
			/\	ոլիավե Ուսենին հարորություններին հարորություն

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)
Parameter	Value
Origin	Bruker BioSpin GmbH
Owner	user1d
Instrument	spect
Solvent	CDCI3
Temperature	298.1
Pulse Sequence	zgpg30
Experiment	1D
Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
Number of Scans	256
Receiver Gain	190.5
Relaxation Delay	2.0000
Pulse Width	10.0000
Acquisition Time	1.0398
Spectrometer Frequency	125.83
Spectral Width	31512.6
Lowest Frequency	-1897.9
Nucleus	13C
Acquired Size	32768
Spectral Size	65536
	Parameter Origin Owner Instrument Solvent Temperature Pulse Sequence Experiment Probe Number of Scans Receiver Gain Receiver Gain Relaxation Delay Pulse Width Acquisition Time Spectrometer Frequency Spectral Width Lowest Frequency Nucleus Acquired Size

أكتب ويجد والتنبية بالبردار والمدين البار أطوا الباري وبنهين ويها النسوي والمردي الأبليان التسأوي أردن

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Parameter	Value		DCM		vcetone	120	
1 Origin	Varian	26 0	30 [		17 4	80 T	
2 Spectrometer	inova		- <u>5</u>		- 2		Me
3 Solvent	CDCI3		Ι		I	I	Me Me
4 Temperature	20.0						
5 Pulse Sequence	s2pul						
6 Experiment	1D						
7 Probe	hcn						
8 Number of Scans	16						
9 Receiver Gain	32						
10 Relaxation Delay	10.0000						
11 Pulse Width	7.0000						
12 Acquisition Time	4.0960						
13 Spectrometer Frequency	500.07						
14 Spectral Width	8000.0						
15 Lowest Frequency	-1521.1						
16 Nucleus	1H						
17 Acquired Size	32768						
18 Spectral Size	65536						
			I				
						i. <b>M</b> II.	
				1		a.WMA.J.W	
		<u> </u>				/www.r M vr(./ww.) (	

... 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value			
1	Origin	Bruker BioSpin GmbH			Me
2	Owner	user1d			
3	Instrument	spect			Me Me
4	Solvent	CDCI3			
5	Temperature	298.1			
6	Pulse Sequence	zgpg30			
7	Experiment	1D			
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)			
9	Number of Scans	256			
10	Receiver Gain	190.5			
11	Relaxation Delay	2.0000			
12	Pulse Width	10.0000			
13	Acquisition Time	1.0398			
14	Spectrometer Frequency	21512.6			
15	Spectral width	31512.0			
10	Lowest Frequency	-1884.9			
1/	Nucleus	130			
10	Acquired Size	52706			
19	spectral size	03330			
					lu .
	, in a line had no little the distribution of the little in the distribution of the di		ينصلينا الترابيا الترا		والمتعادية المتعادية والمتعادية والمتعادية أنتاب والتربية والتحريب والمتعادية والمتعادية والمتعادية التخار
and an	אן זו האנאראר ארט ואברן איז אין איז אווי הבריש או זיי און איי און איין און איין אין איין אי	e in leafe and the sector of the first and a sector in a standard and all the first and a sector sector sector sector first and a sector first and a sector of the first and a sector of t	do. Mirin, Abhardadi.	ىلى بەر ئىلەر ئىلار بىلەر مەيە جايە 10،00 مالەر بەيە ئىلار بەر	וראו אלגלו אנו אנו איני איני איני איני איני איני
20	220 210 200 1		0 70	60 50	
	220 210 200 1	f1 (ppm)	5 70	00 50	10 50 20 10 0 -1

	Parameter	Value	
1	Origin	Bruker BioSpin GmbH	
2	Owner	user1d	
3	Instrument	spect	Me Me
4	Solvent	CDCI3	
5	Temperature	296.2	
6	Pulse Sequence	zg30	
7	Experiment	1D	
8	Probe	Z127784_0002 (CP BBO 500S1 B	BF-H-D-05 Z)
9	Number of Scans	16	
10	Receiver Gain	69.2	
11	Relaxation Delay	10.0000	
12	Pulse Width	12.0000	
13	Presaturation Frequency	1	
14	Spectrometer Frequency	/ 500.35	
15	Spectral Width	10000.0	
16	Lowest Frequency	-1922.2	
17	Nucleus	1H	
18	Acquired Size	32768	
19	Spectral Size	65536	
		~	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

	Parameter	Value	5 CDCI3				
1	Origin	Varian	7.2(				Me
2	Spectrometer	inova					
3	Solvent	CDCI3					Me Me
4	Temperature	20.0					
5	Pulse Sequence	s2pul					
6	Experiment	1D				1	
7	Probe	quadbp					
8	Number of Scans	16					
9	Receiver Gain	56					
10	Relaxation Delay	0.0000					
11	Pulse Width	5.8250					
12	Acquisition Time	4.0960					
13	Spectrometer Frequency	/ 399.74					
14	Spectral Width	8000.0					
15	Lowest Frequency	-2426.5					
16	Nucleus	1H					
17	' Acquired Size	32768					
18	Spectral Size	65536					
						IN A WIND A WINNE	
						MAM. A. A.M.	
inder/proje	ĸĸſĸĸŊŢĸĸſſŊĨĸŢſĸĸĊſĸĬġĸĸĸſĸĬġĬŶĬĬĬĊŢŊĬĬĊĸĬĸĸĬĸĸŢĿĸŢĸĸĬĸĸĬĸĸĬġĬġ	งมีมีรถสมสตร์ได้ให้สองไหนการประกัดที่ไปที่ไทยและให้เกิดการสุดรู้ได้ที่ไปสามังได้สามังได้สามังได้สามังได้สุดรู้ไ	recentry hereasy has supplied and a supplied and the supplication of the supplication	www.l. humansuppersonanterphenessanterphenessanterphenessanterphenessanterphenessanterphenessanterphenessanterp	๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛๛		Weenvandaenversamweensamweensammersamweensamweenverse

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.0 11.5 11.0 10.5 10.0 9.5 9.0 8.0 7.5 6.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 8.5 7.0 6.0 1.0 f1 (ppm)

Parameter	Value	
1 Origin	Bruker BioSpin GmbH	
2 Owner	user1d	Br Me'''
3 Instrument	spect	
4 Solvent	CDCI3	
5 Temperature	296.1	
6 Pulse Sequence	zgpg30	
7 Experiment	1D	
8 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	
9 Number of Scans	1024	
10 Receiver Gain	190.5	
11 Relaxation Delay	2.0000	
12 Pulse Width	10.0000	
13 Acquisition Time	1.0398	
14 Spectrometer Frequence	y 125.83	
15 Spectral Width	31512.6	
16 Lowest Frequency	-1899.9	
17 Nucleus	13C	
18 Acquired Size	32768	
19 Spectral Size	65536	

-1 f1 (ppm) ò

	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Owner	user1d
3	Instrument	spect
4	Solvent	CDCI3
5	Temperature	296.1
6	Pulse Sequence	zgflqn
7	Experiment	1D
8	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
9	Number of Scans	16
10	Receiver Gain	190.5
11	Relaxation Delay	1.0000
12	Pulse Width	15.0000
13	Acquisition Time	0.5767
14	Spectrometer Frequency	470.75
15	Spectral Width	113636.4
16	Lowest Frequency	-103898.1
17	Nucleus	19F
18	Acquired Size	65536
19	Spectral Size	131072







Parameter	Value		DCM		H2O	DMSO	F O O
1 Origin	Varian		5.76		3.33	2.50	
2 Spectrometer	inova				Ĭ		Ma Ni Me'' V
3 Solvent	DMSO						
4 Temperature	20.0						0
5 Pulse Sequence	s2pul						
6 Experiment	1D						
7 Probe	QUAD						
8 Number of Scans	16						
9 Receiver Gain	56						
10 Relaxation Delay	10.0000						
11 Pulse Width	6.5000					I.	
12 Acquisition Time	4.6645						
13 Spectrometer Frequence	y 499.70						
14 Spectral Width	7024.9						
15 Lowest Frequency	-1003.9						
16 Nucleus	1H						
17 Acquired Size	32768						
18 Spectral Size	65536						
				1			
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		)' V'[''[	//			MUL_/ L	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)

Parameter	Value	CDCI3	CH2CI2			N=N N-Me
1 Origin	Bruker BioSpin GmbH	56.	30			
2 Spectrometer	spect		- <sup>2</sup>			
3 Solvent	CDCI3	I	I			N F
4 Temperature	296.2					
5 Pulse Sequence	zg30					AcO — Me
6 Experiment	1D					
7 Probe	Z127784_0002 (CP BBO 500S1	3BF-H-D-05 Z)				
8 Number of Scans	16	1				
9 Receiver Gain	107.0					
10 Relaxation Delay	10.0000					
11 Pulse Width	12.0000					
12 Acquisition Time	3.2768					
13 Spectrometer Frequence	y 500.35					
14 Spectral Width	10000.0					
15 Lowest Frequency	-1922.8					
16 Nucleus	1H					
17 Acquired Size	32768					
18 Spectral Size	65536					
				11		Grease
				11 h		│
	N	N		/////	الا	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)



-1

	Parameter	Value
1	Origin	Varian
2	Spectrometer	inova
3	Temperature	20.0
4	Pulse Sequence	s2pul
5	Experiment	1D
6	Probe	QUADG
7	Number of Scans	0
8	Receiver Gain	4
9	Relaxation Delay	1.0000
10	Pulse Width	33.0000
11	Acquisition Time	0.3277
12	Spectrometer Frequency	469.89
13	Spectral Width	94007.1
14	Lowest Frequency	/ -93996.9
15	Nucleus	19F
16	Acquired Size	30804
17	Spectral Size	65536





.0 11.5 11.0 10.5 10.0 9.5 9.0 8.0 7.5 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 8.5 7.0 6.5 6.0 1.0 f1 (ppm)



	Parameter	Value
1	Origin	Bruker BioSpin GmbH
2	Spectrometer	spect
3	Solvent	CDCI3
4	Temperature	296.2
5	Pulse Sequence	zgflqn
6	Experiment	1D
7	Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)
8	Number of Scans	16
9	Receiver Gain	190.5
10	Relaxation Delay	10.0000
11	Pulse Width	15.0000
12	Acquisition Time	0.5767
13	Spectrometer Frequency	470.75
14	Spectral Width	113636.4
15	Lowest Frequency	-103898.1
16	Nucleus	19F
17	Acquired Size	65536
18	Spectral Size	131072



20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -22 fl (ppm)

1







5.0 f1 (ppm) .0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 5.5 4.5 4.0 3.5 3.0 2.5 2.0 1.5 0.5 0.0 -0.5 -1.0 -1.5 -2 6.5 6.0 1.0

Parameter	Value	EtOAc Grease EtOAc EtOAc
1 Origin	Bruker BioSpin GmbH	<b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b>
2 Spectrometer	spect	
3 Solvent	CDCI3	
4 Temperature	298.2	
5 Pulse Sequence	zgpg30	
6 Experiment	1D	
7 Probe	Z127784_0002 (CP BBO 500S1 BBF-H-D-05 Z)	Ň Ň Ň
8 Number of Scans	368	Me
9 Receiver Gain	190.5	
10 Relaxation Delay	2.0000	
11 Pulse Width	10.0000	
12 Acquisition Time	1.0398	
13 Spectrometer Frequency	y 125.83	
14 Spectral Width	31512.6	
15 Lowest Frequency	-1899.5	
16 Nucleus	13C	
17 Acquired Size	32768	
18 Spectral Size	65536	
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30 220 210 200	190 180 170 160 150 140 130 120 110 100 90 80	70 60 50 40 30 20 10 0 -

Parameter	Value	CDCI3	CH2CI2		
1 Origin	Bruker BioSpin GmbH	. 56	30		
2 Spectrometer	spect	. ~			
3 Solvent	CDCI3	I	I	L I I	Ĥ
4 Temperature	296.1			AcO'	
5 Pulse Sequence	zg30			We	
6 Experiment	1D				
7 Probe	Z127784_0002 (CP BBO 500S1 B	3BF-H-D-05 Z)			
8 Number of Scans	16				
9 Receiver Gain	190.5				
10 Relaxation Delay	30.0000				
11 Pulse Width	12.0000				
12 Acquisition Time	3.2768				
13 Spectrometer Frequenc	y 500.35				
14 Spectral Width	10000.0				
15 Lowest Frequency	-1747.7				
16 Nucleus	1H				
17 Acquired Size	32768			1	
18 Spectral Size	65536				
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	///			/I//IA_/\/WM#%*#"''WA_##/WHA_/	

LO 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2 f1 (ppm)









5.0 f1 (ppm) 9.0 8.5 4.5 2.5 2.0 1.5 1.0 <sup>-1.5</sup> -2 351 1.0 11.5 11.0 10.5 10.0 9.5 8.0 7.5 7.0 6.5 6.0 5.5 4.0 3.5 3.0 0.5 0.0 -0.5 -1.0

		Parameter				Ň	/alue																
1	Orig	gin		Bruker E	lioSpin	GmbH									9								Me
2	2 Spe	ectrometer		spect											i							Me	
Э	B Solv	vent		CDCI3																	[	, Î Ĥ	Ē
2	l Ten	mperature		296.2																	HO	∕¦∕	
5	5 Puls	se Sequence	:	zgpg30																		Me	
e	6 Exp	periment		1D																			
7	7 Pro	be		Z12778	4_0002	2 (CP B	BO 500	S1 BBF-⊦	H-D-05	Z)													
8	3 Nur	mber of Scans		368																			
ç	Rec	ceiver Gain		190.5																			
1	LO Rela	axation Delay		2.0000																			
1	1 Puls	se Width		10.0000	)																		
1	2 Acq	quisition Time		1.0398																			
1	L3 Spe	ectrometer Fred	quency	125.83																			
1	L4 Spe	ectral Width		31512.6	5																		
1	L5 Low	west Frequency		-1899.1																			
1	L6 Nuc	cleus		13C																			
1	17 Acq	quired Size		32768																			
1	L8 Spe	ectral Size		55536																			
								. []															
hajanaki	<b>Muhyhh</b> hh	ing ing and a start of the star	nder of the second s	in Manun Man	Anini Maningi	nibikirki	444 <b>()</b> 44 <b>64)</b> 44	hen proglad v Jong	l la la nu la	linnin an	fini fini fini fini fini fini fini fini	ninininini <mark>nin</mark> inini	udhandhinipita	indinia	uwwanimool (	Mana and a second s	<b>ita</b> num haipidab	n affin i an	<b>h</b> ann an thair an an thair an an thair	wyddi (Wdynydyn	la l	hladina in the first of the fir	yddy, 4ani Millig ydda yddigy
30	220	210 20	0 19	90 1	80	170	160	150	140	130	120	110 f1 (ppm)	100	90	80	70	60	50	40	30	20	10	01 352











